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The Magazine of Space Exploration

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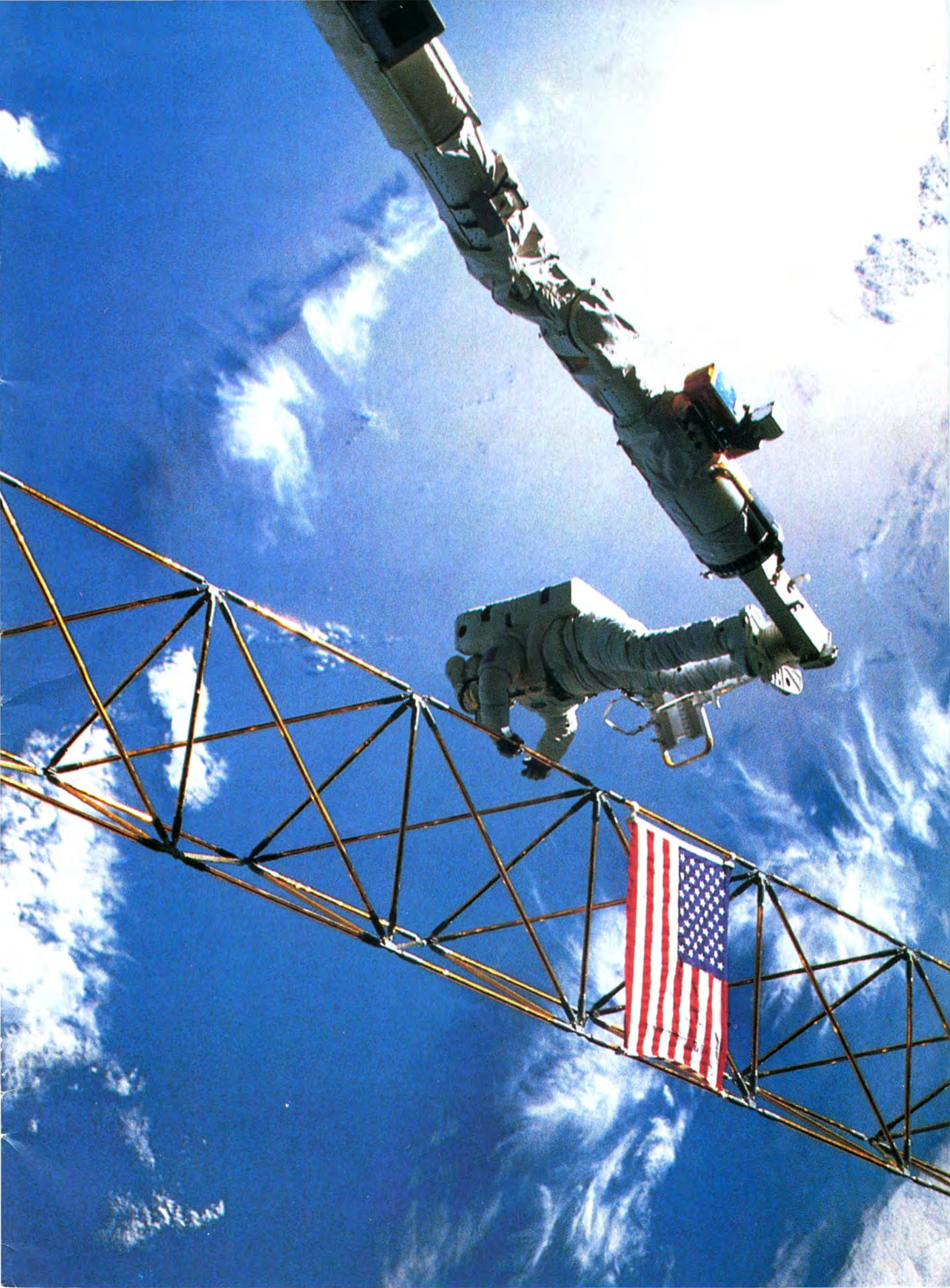

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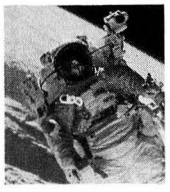

Ever wonder what it's like to go solo in space? So did we. See the article beginning on page 20.

Volume 1, Number 2

Features

Departments

FINAL FRONTIER is published bimonthly by Final Frontier Publishing Company, 339 Union Plaza, 333 N. Washington Ave., Minneapolis, MN 55401. Application to mail at second class rate is pending at Minneapolis, MN. Subscriptions in the U.S.A., its territories and possessions, $14.95 for the year (6 issues). For other countries, including Canada, add $5 for postage. Postmaster: Please send change of address notice form 3579 to FINAL FRONTIER, 339 Union Plaza, 333 N. Washington Ave., Minneapolis, MN 55401. Printed in the U.S.A. Mailed at Minneapolis, Minnesota and additional entry points. Certain editions may contain pages 16A & B and 48A & B.

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From The Publisher

I would never hire someone who had my qualifications. This job requires a writer and a rocket scientist. I'm neither.

All I do is try to infect more talented people with my fanaticism for space. When that fails, I use coercion.

It doesn't happen very often; talented people are very interested in space.

Final Frontier was envisioned as a limited-interest magazine. But I'm finding out that there's nothing limited about the subject of space.

Interest is so high that this, the second issue of Final Frontier, is already crossing international borders from Minneapolis to Sydney. It's only right.

As the magazine travels, so travels our office. We've moved out of our room in the back of a Standard station. In fact, we've moved twice this month. But we're still far enough from legitimacy to be inspired.

Apparently the message is getting out. Officials from NASA to Moscow have called. And I just finished talking to a guy from Germany who called to bolster our spirits during our round the clock sessions before going to press.

The mail is multiplying. The number of writers and readers is rising. The mission of space exploration is a lot bigger than a few buffs and their magazine. And thank God for that.

In a novel, Saul Bellow once described someone's mind as the "sponge through which the ocean passes" or something close to that.

At Final Frontier, we're the dish to which the universe transmits. In other words, we're just a conduit for a powerful wealth of talent and inspiration that's much greater than we are. Let's hope it keeps on.

Ever upward,

William Rooney

William Rooney
Publisher

FINAL FRONTIER
THE MAGAZINE OF SPACE EXPLORATION

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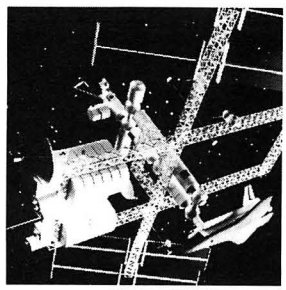
PUBLISHING, EDITORIAL AND PRODUCTION OFFICE: FINAL FRONTIER, 339 Union Plaza, 333 North Washington Avenue, Minneapolis, MN 55401 (612) 349-2733. President: William Rooney. Founder: Robert Welch. Chairman and Chief Financial Officer: Robert Carroll. Advisory Board: Paul Tallis, V. Lindy Spassenko, Romney Tripp, Greg Mananian, Burten Carraher, Timothy Johnson, Charles Allen.

EDITORIAL CORRESPONDENCE: Send submissions c/o the Editor, FINAL FRONTIER, P.O. Box 11519, Washington, D.C. 20008. We cannot be responsible for unsolicited material or photos. Article submissions must be accompanied by a self-addressed, stamped envelope.

SUBSCRIPTION SERVICE: Mail all subscription orders, changes of address (include latest label or give both old and new address) and other subscription correspondence to: FINAL FRONTIER, 339 Union Plaza, 333 North Washington Avenue, Minneapolis, MN 55401. (612) 884-6420.



America needs the Space Station.

There are practical reasons to be first in space. It's a good investment, for example. Research and technological innovation connected with the space program have increased the rate of invention, boosted productivity, raised our standard of living and broadened our economic base.

Then, too, it's better to be first than last.

Japan and the nations of Europe have active space programs. So does the USSR, with astronaut-scientists from Vietnam, Hungary, East Germany, Cuba, Poland and Czechoslovakia. Russia's space station is operational now.

Like all frontiers, space is a test of the human spirit. It requires a vision of the future, a sense of adventure, courage, resolve and the will to explore boldly when it's more comfortable to stay home.

America *can* be first in space. Our culture encourages new ideas and exploration. Space research is this generation's call to greatness. History awaits our response.

BOEING

LETTERS

TOM R. GARRETT

Congrats

First, let me say that FINAL FRONTIER is the best magazine I have ever read. The stories were on subjects of great interest to me, and they were written in a style and with such depth that I felt I was getting real information — for a change. After two frustrating years of trying to find out what was happening in space for less than $385 per year, I find that you have provided much of the information already — and it's just your first issue!

Robert W. Stephenson
Cape May, NJ

I've seen a copy of your first issue and it looks great! Congratulations on a first class job. I'll be looking forward to the next issue — as a subscriber.

John Rhea, Editor
Space World
Washington, D.C.

Congratulations on a super magazine, and a great format! Space exploration has truly come of age if the industry will support a publication such as yours.

Frank Sietzen, Jr.
New Orleans, LA

Thanks for the premier issue of FINAL FRONTIER. It's a gem for anyone who enjoys the business and research of space. Keep up the good work.

Bob Hardy
KMOX Radio
St. Louis, MO

Congratulations on Volume 1, Issue 1 of FINAL FRONTIER.

Charles R. Berry, Advertising Director
Air and Space Magazine
New York, NY

First and foremost let me congratulate you on your first issue of a fine publication. I, the technical people, and the American public deserve the facts as presented. I hope that your reception will be outstanding.

Alfred J. Zaehringer
Birmingham, MI

Misnomer

Please allow me to set the record straight on a common misconception that you have helped to perpetuate in your first issue of FINAL FRONTIER. In numerous places in your most interesting magazine, the misnomer expression "NASA Jet Propulsion Lab" (or variants) was used.

In actual fact, the Jet Propulsion Laboratory (JPL) is, and always has been, an integral part of the California Institute of Technology (Cal Tech). Furthermore, the lion's share of JPL funding has always come, directly or indirectly, from the Department of Defense (DOD). While it is true that some NASA staff are assigned to work at JPL, they are mostly in contract monitor positions: even though they have wrested a unique contractual relationship, JPL is definitely no more a part of NASA than any other government contractor organization!

Lindsey V. Maness, Jr., President
Petro Image Corporation
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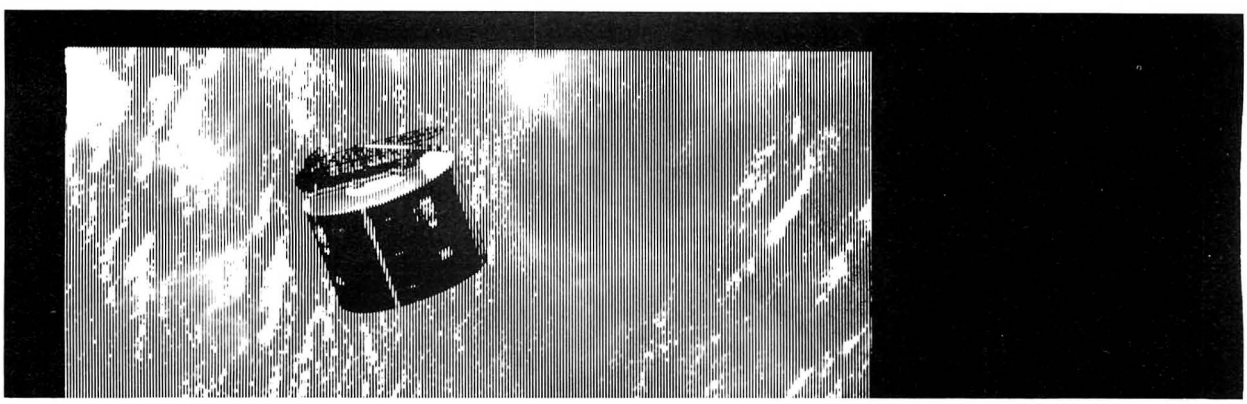


The Space Station's potential for improving life on our planet is boundless. Yet the cost of building and maintaining it comes to roughly two cents a day for every American. Your support for the NASA Space Station will make a difference. So get your two cents' worth in. Say yes to America's manned space station program.

MCDONNELL DOUGLAS

THE OBSERVATORY

The Space Settlement Act

A bill for the long-term future

▼ ▼ ▼

By Congressman George E. Brown, Jr.

The President's new National Space Policy states for the first time that a long-range goal for the U.S. is "to expand human presence and activity beyond Earth orbit into the solar system." Manned exploration of space beyond Earth orbit has always been an implicit goal of NASA, as can be seen by the Apollo Moon project. The articulation of that goal, however, gives credence to future objectives in space, such as further exploration of the Moon, and manned exploration of Mars and other celestial bodies in the Solar System.

Certainly the President's policy has some exciting implications, but I think it can be expanded further. If the goal is to extend human activities beyond Earth orbit, then it is possible to determine, at least in general terms, where that extension will eventually lead. Complex scenarios are not required to visualize the desirability, at some point in the future, of establishing self-sufficient settlements in space. It will become increasingly inefficient to keep space researchers and workers in cramped quarters, dependent on supply lines from Earth.

In this scenario, space settlements can be considered a benchmark for progress in space. With the establishment of space settlements, input of Earth resources is dramatically reduced, while activities in space can increase exponentially. Further, the world would benefit proportionally, through such things as spinoff technologies, finished products and, perhaps, critical raw materials and solar power satellites.

If we have general agreement that space settlements are a logical outgrowth of activities in space, is anything stopping us from clearly stating that intent? Certainly not. For this reason, I am proposing legislation to amend The National Aeronautics and Space Act of 1958, to set the establishment of space settlements as a long-term mission for the space agency. This bill, The Space Settlement Act of 1988, is expected to be introduced in Congress by the time you read this.

The 1986 report of the National Commission on Space was called *Pioneering the Space Frontier.* For me, the term "pioneering" evokes images of settlers and homesteaders, rather than Lewis and Clark-style explorers. The Commission described space settlements as part of the long-term framework of human evolution into space. Unfortunately, our space program today is only attuned to the astronaut as explorer, and does not recognize that space can be opened for a much larger cross-section of society as pioneers.

Even last year's NASA report on space leadership by Dr. Sally Ride states, "Exploring, prospecting, and settling are parts of our heritage, and will most assuredly be part of our future." We can state without argument that today's space program is geared toward exploration and prospecting, but we have no policy with respect to settling the space frontier. In my opinion this is a great oversight. By ignoring the settlement of space as a legitimate eventuality, we deny ourselves near-term understanding of where we are heading in space.

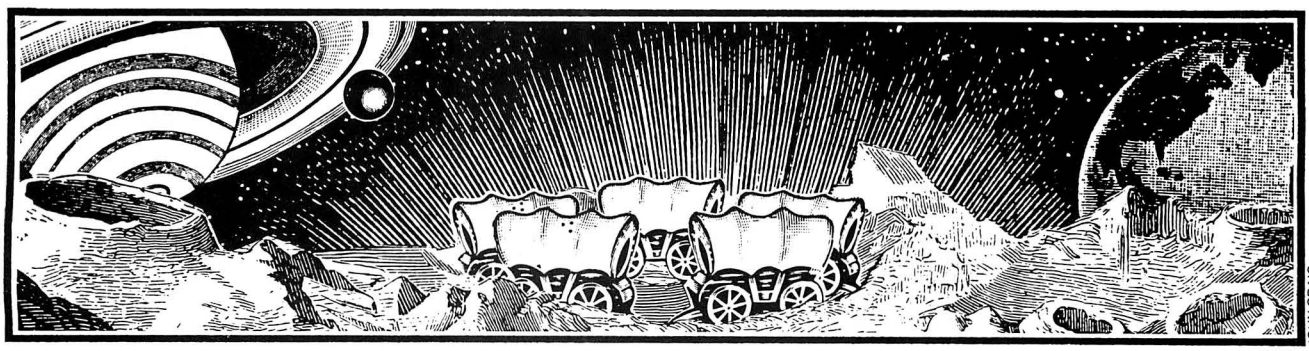
Our true long-term goals in space are to open the Solar System to scientific investigation, manned and unmanned exploration, and commercial and social development. The Space Settlement Act of 1988 is merely a tool to improve our ability to pursue these goals. My bill would not dictate where, how, or when to construct a settlement — to do so at this point would be irresponsible. The legislation simply sets the settlement of space as a legitimate long-range objective. It also requires NASA to be the lead agency in conducting a steady low-level effort to explore all the scientific, technical, and sociological issues relating to the achievement of this goal.

In a speech delivered in October 1987, NASA Administrator James Fletcher speculated on the prospects for space settlements. He said in his remarks that "space colonies would be settled by pioneers, by people with daring and inquisitiveness and exuberance — people who wanted to strike out for a new life." In his summary, Fletcher defended his views by quoting from the Book of Proverbs, "Where there is no vision, the people perish." These are words we need to inspire generations of Americans to achieve greatness.

If you share these views, please contact your Congressman, and urge him or her to co-sponsor The Space Settlement Act of 1988. □

George E. Brown Jr.

George Brown is a Democratic Congressman from California, and Co-Chairman of the Congressional Space Caucus.



JOHN CRAIG

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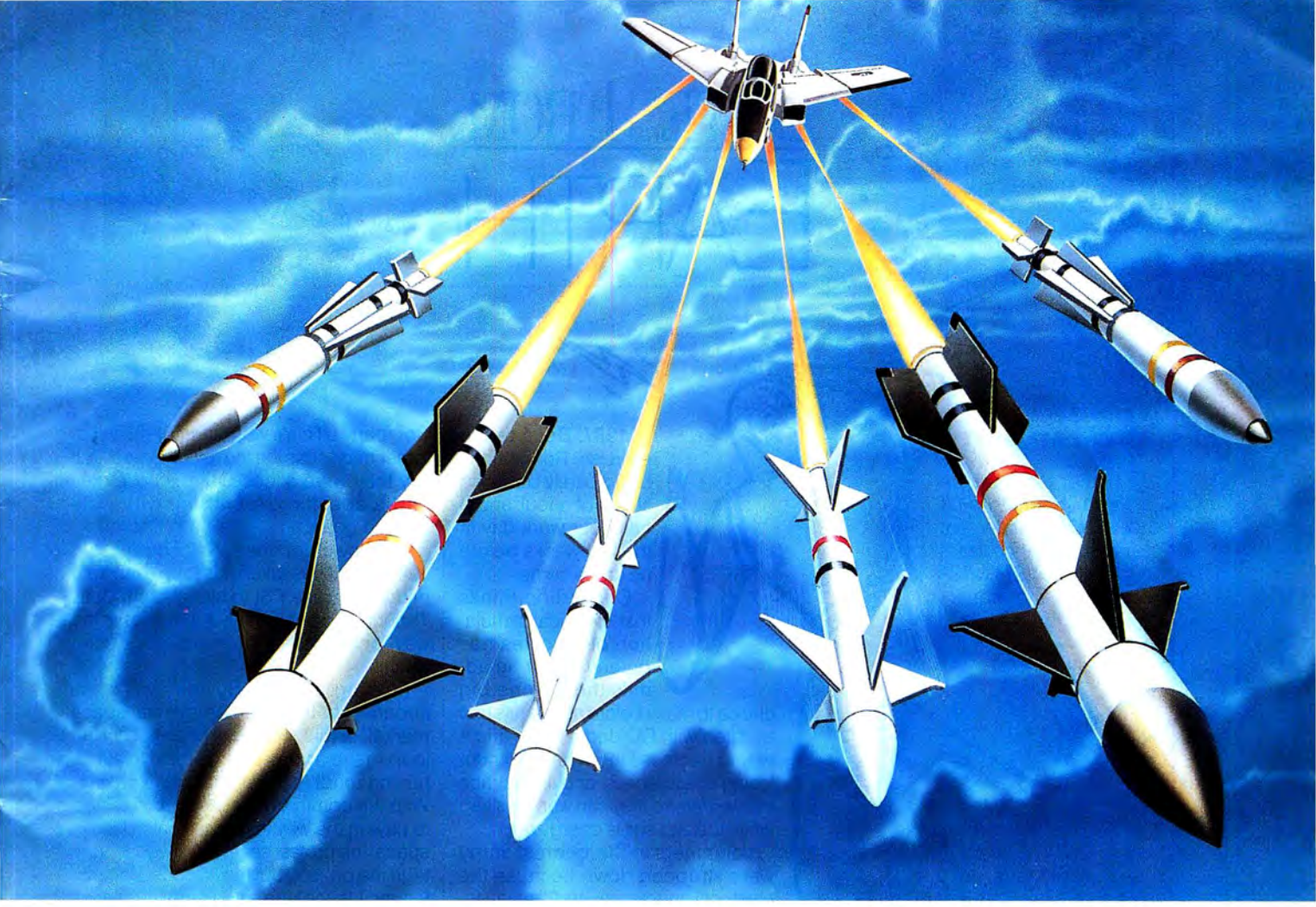

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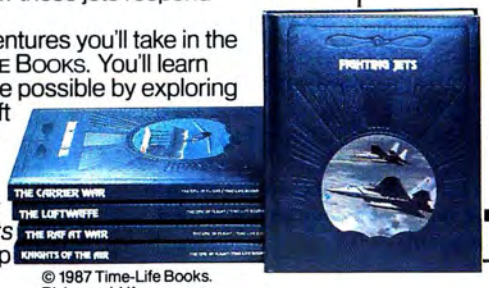

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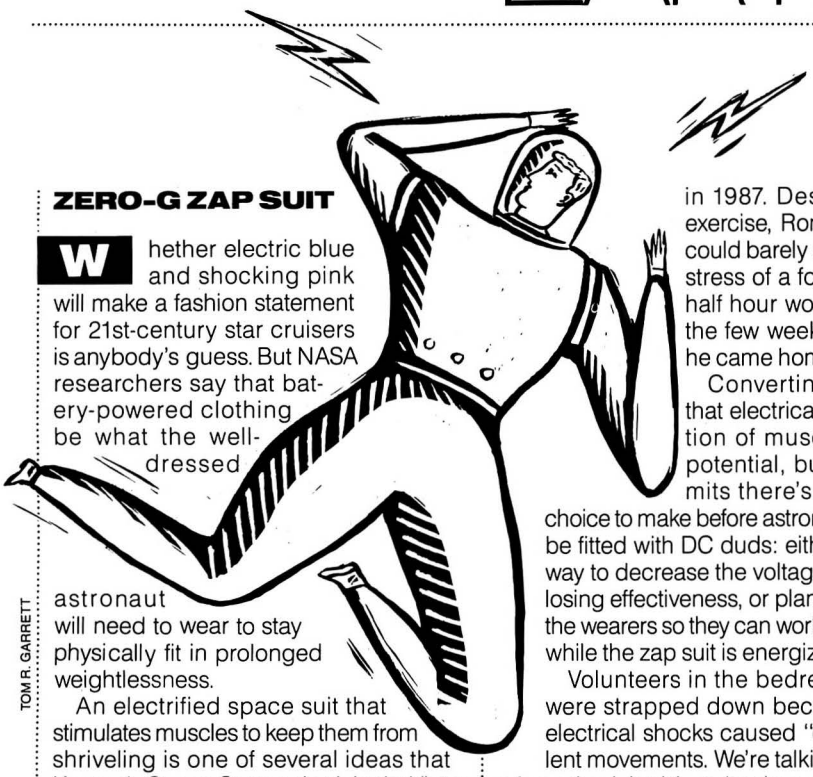


TOM R. GARRETT

ZERO-G ZAP SUIT

Whether electric blue and shocking pink will make a fashion statement for 21st-century star cruisers is anybody's guess. But NASA researchers say that battery-powered clothing may be what the well-dressed astronaut will need to wear to stay physically fit in prolonged weightlessness.

An electrified space suit that stimulates muscles to keep them from shriveling is one of several ideas that Kennedy Space Center physiologist Victor Convertino and his colleagues are discussing as they continue to investigate how long-term exposure to microgravity affects the human body. Knowing that weightlessness weakens muscles because it reduces exertion, the scientists are studying ways to prevent the atrophy that makes some astronauts too weak to walk when they return to terra firma.

In an experiment at NASA's Ames Research Center in California last year, Convertino's group subjected volunteers to 30 days of around-the-clock bedrest (to decrease muscle use) and periodic jolts of electricity. They planned to release the results of the experiment this spring.

Besides preventing atrophy, Convertino speculates a "zap suit undergarment that provided mild electrical stimulation to flex muscles might save more than ten percent of an astronaut's time. Exercise [the current method of maintaining muscle tone in space] takes a dedicated amount of time away from operations," he explained. "We would like to minimize that so the astronauts are as productive as they can be during a normal six- or eight-hour work day in orbit."

Cosmonaut Yuri Romanenko pedalled a stationary bicycle and jogged a treadmill for two and a half hours on each of the record-breaking 326 days he spent aboard the Soviet space station Mir in 1987. Despite the exercise, Romanenko could barely stand the stress of a four and a half hour work day in the few weeks before he came home.

Convertino thinks that electrical stimulation of muscles has potential, but he admits there's one big choice to make before astronauts can be fitted with DC duds: either find a way to decrease the voltage without losing effectiveness, or plan to brace the wearers so they can work or sleep while the zap suit is energized.

Volunteers in the bedrest study were strapped down because the electrical shocks caused "quite violent movements. We're talking about a force that jolted them backwards in their seats," Convertino recalled. "You couldn't have astronauts moving around in the cabin and wearing the suits because they'd be spinning all different directions in orbit."

– Beth Dickey

TO MIR WITH LOVE

Democratic Congressman Bill Nelson of Florida, one-time NASA astronaut and consummate space booster, would surely be the last to stand in the way of a U.S. commercial space venture — right? Right — until a Massachusetts company succeeded in booking flights for its customers on the Soviets' Mir space station without consulting him.

Payload Systems Inc. says it "played by the book" to win both Soviet and U.S. approval for its Mir experiment program. Travelling routine bureaucratic byways, the company — one of whose founders, Byron Lichtenberg, ran experiments onboard the shuttle in 1983 — applied to the U.S. Commerce Department and received an export license for an apparatus that will house growing protein crystals aboard the Soviet space station beginning next year.

Company officials won't identify their customer or discuss the terms of the deal, but say they were successful because they had a specific experiment with well-defined goals.

The Soviets opened Mir for business in 1986, and it has taken this long even for a middleman like PSI to strike a firm deal. Though narrowly defined, it may pave the way for other agreements by U.S. companies.

Fearing that the Soviets will make inroads into the U.S. commercial space market, or that NASA will be left out of the loop in the approval process, Nelson is hurling roadblocks in front of the project. With the administration newly committed to paving the way for private enterprise in space, the protest seems unlikely to sabotage the project, but the National Security Council is looking into licensing issues nonetheless.

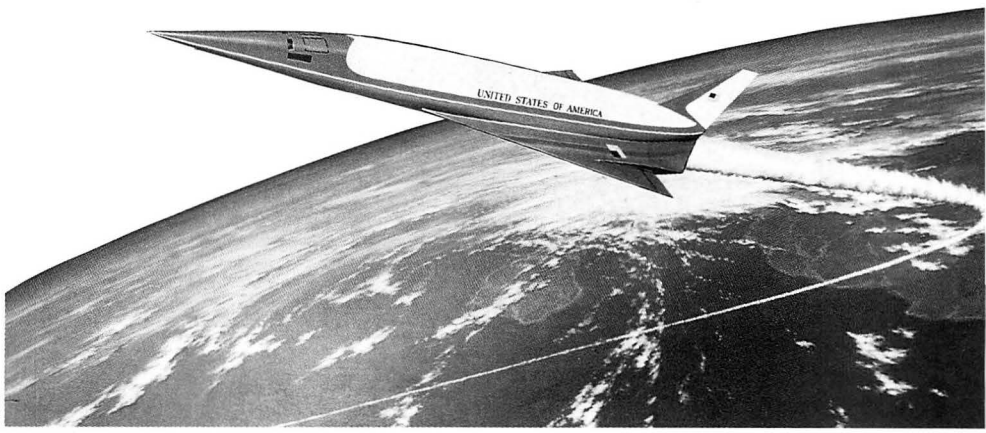
PSI still has a year to leap any barriers erected by Nelson or others. "We're just trying to give our customers access to space. . . . You might say we've got our feet more firmly planted on the ground than some" in the space business, says director of business development Vinit Nijhawan. "We have a very simple test for companies who say they can provide us with a microgravity environment — how much does it cost and when can I fly?"

The Soviets, apparently, had all the right answers.

– Melinda Gipson

NASA

Byron Lichtenberg onboard Spacelab in 1983, before he became an orbital real estate agent.



NASA

Final blueprints for the National Aerospace Plane may omit the windows.

WHO'LL DRIVE THE DRAGON?

Depending upon who you ask, the National Aerospace Plane program is either roaring along at Mach 25 or doomed for lack of funding. Design of the "scramjet" engine that will breathe in oxygen from the atmosphere is well underway, the thermal and aerodynamic puzzles are no longer as mystifying as they once were, and the charts still call for a first test flight in 1993.

But how to drive this air-breathing, fire-belching dragon from a runway into orbit at 25 times the speed of sound is another matter.

Chuck Yeager, the test pilot who broke the sound barrier, has already made it known that he'd love to be at the controls when the dragon delivers its first payload to orbit. Other pilots aren't so sure, because no one knows yet what this plane is all about. Will it take one pilot or a whole crew to manage the instruments and information necessary to fly the space plane?

The Defense Advanced Research Projects (DARPA) office says it hasn't gotten far enough to know who's going to fly the space plane, but DARPA says there's a "brief investigation" being conducted by the Joint Program Office at Wright Patterson Air Force Base in Dayton, Ohio. In addition to that work, industry contractors are hammering out the details of cockpit design, instrumentation and flight information management.

The DARPA program office makes the pilot's job sound simple: It will be something like "flying a computer that's flying the plane." There are no windows designed into the needle nose of the space plane, and there probably won't be. After all, what kind of decisions will a pilot be able to make at Mach 25? One industry spokesperson gave these pilot specs: "If your daddy was a fighter pilot and your momma was an astronaut, you'd be in good shape to fly the space plane."

Describing the first flights, an engineer working on the program said, "You know, there's no place on Earth we can test all that needs to be really tested before this plane takes off from the runway. We have to open the envelope a step at a time."

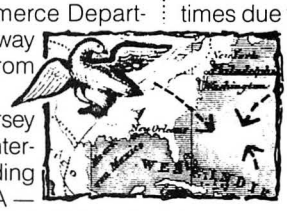
When President Reagan mentioned the space plane in his 1986 State of the Union address to Congress, he referred to it as the "Orient Express," conjuring an image of passengers sipping coffee on their two-hour flight to Tokyo. But DARPA is quick to point out that "the technologies we are developing and perfecting for the aerospace plane will be transferred to the commercial version, to the plane the President called the 'Orient Express.' But it's not the same plane."

Even all the unknowns don't seem to dampen the enthusiasm of pilots eager to explore the frontiers of space. When asked if driving the dragon would appeal to him, one pilot said, "Hey, I don't even know what it's going to finally look like. But, sure, I'd fly it!"

– Robert Moulton

WASTE IS A TERRIBLE THING TO MIND

Polluting the ocean is illegal. It's also very difficult to stop. Barge owners can dump garbage, sewage sludge, or acid waste in the waters off the New York and New Jersey coasts without being observed by anyone but the sea gulls. Now the U.S. Commerce Department is exploring another way to get a bird's eye view: from satellites.



At the request of New Jersey Senator Bill Bradley, an Interagency Task force — including NASA, NOAA, and the EPA — is examining the use of weather and Earth observation satellites to enforce environmental protection laws.

Meteorological satellites, such as NASA's Nimbus series and the current NOAA family, can sense heat discharged from power plants and plumes of sediment in polluted rivers. The Coastal Zone Color Scanner instrument on Nimbus even spotted acid waste dumps off the New Jersey coast: the acid, generated by metal-processing plants farther inland, is so powerful that it marks the wake of the barge with a bright orange trace that's visible for days.

High-resolution sensors on Earth observation satellites, such as Landsat and the French SPOT, can also pick out waste dumps and could possibly detect the barges themselves.

Future satellites will be equally capable. A Sea-viewing, Wide-Field-of-View Sensor (Sea-WiFS, for short) will fly on the next Landsat. A Moderate-Resolution Imaging Spectrometer is planned for the space station platforms in the 1990s.

And there's still room for private satellites. Gregg Fawkes, Director of the Commerce Department's new Office of Commercial Space Programs, suggests placing a sensor in an equatorial orbit to patrol the coast every six to eight hours. The cost to New Jersey would be less than the tourist money it's now losing; last year the state's beaches had to be closed 15 times due to garbage washing ashore.

"The demand for tracking this waste could fuel private development of satellites," says Bradley. More satellites in the sky should deter barge owners from dumping illegally. "We want to send a message: you're taking a risk when you dump on New Jersey shores." For now, the long view of satellites may be the best assistant to the long arm of the law in keeping the coasts litter-free.

– Joanne Heckman

NOTES FROM EARTH

NASA

A rover/sampler mission would poke around among the Martian rocks that Viking only photographed in 1976.

A MARS SAMPLER

An ambitious U.S. mission to explore Mars with robots before the end of this century has become one step closer to reality, thanks to work being done for NASA by the U.S. Geological Survey.

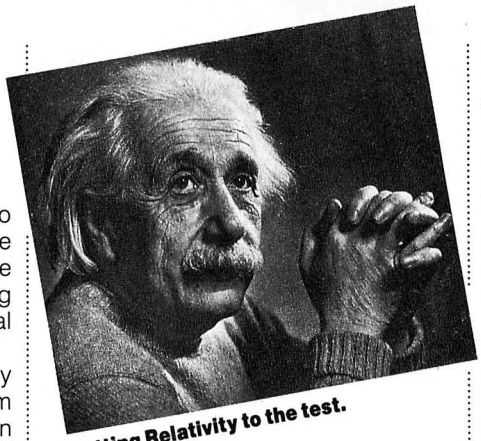
Scientists there are using specially enhanced, high-resolution photos from the Viking spacecraft that touched down on Mars in 1976 along with radar studies from Earth and from Viking orbiters to study the geology and surface roughness of a variety of Martian sites.

From this work, NASA hopes to select a site for landing and maneuvering a Mars rover and sample-return mission in the not-too-distant future. Scientists recognize that the optimum terrain for such a site should be smooth, and that it should offer geologic samples of widely varying ages and chemical compositions so that a roving vehicle could collect its rocks quickly and efficiently.

Studies of the Mangala Valles region just south of the Martian equator are virtually complete. They reveal that its ancient cratered terrain is partly covered by volcanic features and rocks. At least three episodes of small-channel formation have been identified and dated.

Perhaps the smoothest areas on the planet, however, appear to be the Chasma Boreale (north polar) and Planum Australe (south polar) regions. A drill mounted on a rover could obtain meter-thick cores of these ice and rock-layered deposits — taken from their natural resting places rather than mixed in with impact debris — and provide a valuable record of the recent history of the planet.

– Dennis Mammana



Putting Relativity to the test.

WAS EINSTEIN RIGHT?

According to Nobel-prize-winning physicist C.N. Yang, "Einstein's General Relativity Theory, though profoundly beautiful, is likely to be amended . . ."

In fact, much of the famed theory remains untested, says Stanford University physicist Francis Everitt. That's where a NASA project called "Gravity Probe B" comes in. Using state-of-the-art physics and engineering developed at Stanford's High Energy Physics Lab, the probe will place four exquisitely precise gyroscopes made of quartz glass into a pole-to-pole orbit 400 miles above the Earth's surface sometime in 1994.

Perfectly round to within about half a millionth of an inch, these spheres spin at a revved-up 10,000 RPM while electrically suspended in a vacuum. A giant, highly insulated "thermos bottle" containing 400 gallons of liquid helium will keep the experiment at a cool two degrees above absolute zero (-273 degrees Centigrade).

The basic idea, says Everitt, is that "very carefully made spinning bodies [if undisturbed] tend to point in the same direction for all time." But not if they are in close proximity to a large body, according to Einstein's General Theory, where gravity distorts space-time.

So, as Gravity Probe B travels through Earth-warped space-time, the gyroscopes should slowly drift away from their original position. "This effect," says Everitt, "has never been tested," but calculations predict a deviation of about 6.6 arcseconds (a measure of angular distance) a year.

A second effect should turn up, too. If Einstein was right, the Earth's spin gradually drags space-time along with it. This "frame-dragging" phenomenon should shift the gyroscopes in a second direction at right angles to the first. "Nothing like that has ever been observed," says Everitt, who expects the measured results to be smaller than a milliarc second (the width of a human hair as seen from 10 miles away).

Remarks Yang of the Stanford experiment, "I would not be surprised at all if it gives a result in disagreement with Einstein's theory." Tune in sometime in the mid-1990s, folks, for the answer.

– Ray Spangenburg/Diane Moser

RAIL-GUN EXPRESS

The Strategic Defense Initiative may soon generate its first spin-off in the area of civilian space technology. Electromagnetic launchers, also called rail-guns, are being designed to shoot projectiles at incoming missiles, but they can also be used to send interplanetary probes hurtling through the Solar System, according to Ross M. Jones of NASA's Jet Propulsion Laboratory.

Using electrical impulses, "experimental rail-guns have demonstrated launch velocities of 10 kilometers/sec," Jones said, and velocities up to 50 km/sec. are possible. At 10 km/sec. a projectile launched from a rail-gun in low-Earth orbit "would reach Saturn in a little over two years," Jones explains. The Voyager 2 space

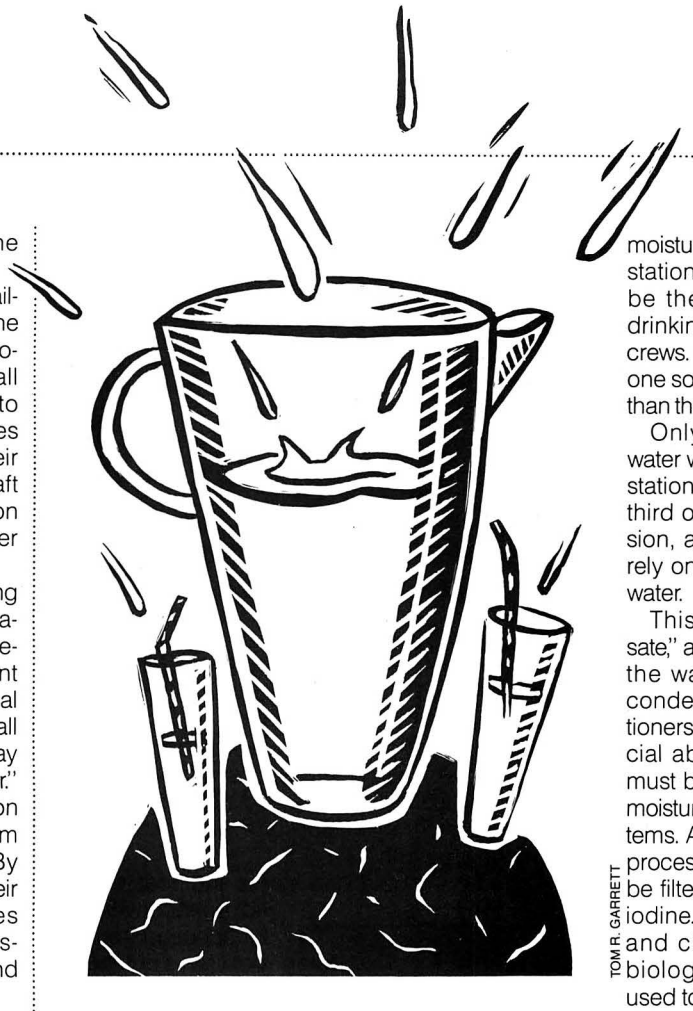
probe took twice that long to reach the ringed planet.

An interplanetary probe shot from a rail-gun would have to be very small, about the size of a coffee can, and weigh only a kilogram. Miniature electronics and small scale construction make it possible to build such small vehicles, which Jones calls micro-spacecraft. Because of their size and simplicity, a micro-spacecraft could be built and launched for a fraction of the cost of a single Voyager or Pioneer space probe.

A break with NASA's tradition of building large, sophisticated spacecraft with a stable of onboard equipment, micro-spacecraft will carry only a single instrument package. Jones speculated that a typical payload might consist of a "single small camera or imaging system, a cosmic ray detector, or a gamma ray spectrometer." One idea is to place radio transmitters on a fleet of micro-satellites and hurl them toward the edge of the Solar System. By tracking the spacecraft and checking their trajectories for perturbations, Jones explained that astronomers might discover if there are any planets out beyond Pluto.

NASA has recently indicated an interest in the micro-satellite/rail-gun concept, Jones said. The next step is to organize a workshop with scientists and people from the Strategic Defense Initiative organization to see if rail-guns are a practical alternative to traditional launch vehicles. If they are, this would be one example of how military technology might be turned to peaceful, scientific purposes.

– *Robert Nichols*



TOM R. GARRETT

WATER, WATER EVERYWHERE

If Coleridge's ancient mariner had met the designers of the NASA space station of the 1990s, he might have said, "Water, water everywhere, more than I can drink."

According to Dick Sauer, Manager of the Water and Food Analysis Laboratory at the Johnson Space Center in Houston, moisture condensed from the station's cooling system will be the primary source of drinking water for astronaut crews. In fact, water from this one source will provide more than the entire crew can drink.

Only a small amount of water will be carried up to the station from Earth. After the third or fourth day of a mission, astronauts will have to rely on recycled condensed water.

This "humidity condensate," as it's called, is similar to the water generated from condensation on air conditioners. Without gravity, special absorption techniques must be used to capture the moisture from the cooling systems. As part of the recycling process, the condensate will be filtered, then treated with iodine. Sauer says physical and chemical rather than biological systems will be used to treat the water.

Wash water and urine also will be recycled and used for bathing and cleaning. Although the thought of drinking recycled urine is not particularly appealing, and is not being considered for the station, it may actually be more pure than the humidity condensate. The properties of urine are known, whereas the condensate will contain unknown variables from the space station environment. Each water source goes through a different recycling process, but all water is treated with iodine in the final stages. The recycling process will take place continually and automatically, but special kits to test water quality will be available if crewmembers suspect contamination.

What does recycled space water taste like? NASA isn't going to wait until the station is built to find out the answer, but they may have to wait longer than expected. A demonstration of several concepts was scheduled for this year, but has been delayed for lack of funding.

– *Linda Kofler*

GENERAL DYNAMICS

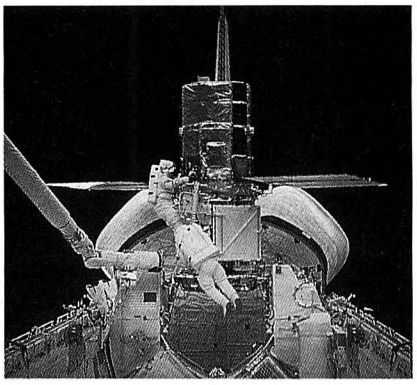
Rail-guns used to launch SDI "interceptors" like the one shown here might also be used to send small probes to other planets.

NOTES FROM EARTH

ROLL CAMERAS

It might be considered a cinematic version of Soviet Glasnost. That's the sense you get when hearing the plans being made by the Smithsonian's National Air and Space museum and the IMAX Systems Corp. of Toronto, Canada, who are scripting a film to highlight the world's space programs, starring the Soviet Mir space station. The scheduled release date is 1992 to coincide with the International Space Year (ISY). Projected cost of the celluloid revue of space ventures from around the globe: $9 million.

The ISY film would follow in the footsteps — or sprocket holes — of another "made in space" epic: *The Dream is Alive*. That IMAX film incorporated footage shot in orbit during three separate space shuttle flights. Deployment of satellites, on-orbit repair of spacecraft, spacewalking, and the day-to-day routine of eating and sleeping were captured by shuttle crews turned moviemakers.



ing an IMAX camera in the Soviet space station has been underway for nearly a year. "We have proposed to film *with* the Russians, not just send a team over and film the Soviet space program. We would work with them and train cosmonauts to use the camera, and we expect to work with a Russian director and cinematographer."

To date, only smiles and nods of semi-approval have been forthcoming from Soviet space authorities. No formal agreement has been sealed. But Duff recently discussed the plan with Soviet cosmonaut, Alexei Leonov, the first human to stroll in space back in 1965.

While visiting the museum earlier this year, Leonov was shown *The Dream is Alive*. "After the film was over," Duff recalls, "he slapped me on the shoulder and said 'that's fantastic,' then asked a number of technical questions about the camera and what we were doing to get the system on Mir." The cosmonaut advised Duff, in effect, to keep up the pressure and be persistent.

THRESHOLD CORPORATION THE SMITHSONIAN INSTITUTION AND LOCKHEED CORPORATION

On-location shot (top and above), from *The Dream is Alive*. The next IMAX epic filmed in space will likely feature an international cast.

As part of the world-wide negotiations, discussions are underway to stow a $1 million IMAX camera onboard the Russian Mir space station. Recently, the U.S.S.R.'s space complex was the home-away-from-home for one cosmonaut who lived there for a record 326 days.

According to Brian Duff, associate director for external affairs at the Air and Space Museum, serious talk about placing an IMAX camera in the Soviet space station has been underway for nearly a year. "We have proposed to film *with* the Russians, not just send a team over and film the Soviet space program. We would work with them and train cosmonauts to use the camera, and we expect to work with a Russian director and cinematographer."

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One proposed clause in the deal is the building of an IMAX theatre in the Soviet Union, possibly in Moscow. The specially-equipped theaters project the film on a dome or on a screen nine times larger than in a conventional theatre. Cost of an IMAX theater can run from $3 million to $9 million.

Hopefully, the ISY film is a forerunner of other cinematic projects designed to benefit Earth-bound, arm-chair astronauts. IMAX cameras will be aboard future space shuttle missions. In addition, preliminary talks have been held to have the U.S. space station carry an IMAX camera on a permanent basis, with film part of the regular resupply order from Earth.

"Photography is a critical part of any space mission," adds Duff. "The great imagery from both manned and unmanned spacecraft has clearly had a massive impact on a generation. The ISY film will show a maturing space program, a second generation space program, a world program as it moves into space."

– Leonard David

GALACTIC EVENTS

June 20-August 20, Cambridge, Massachusetts. The first summer session of the International Space University will bring graduate students from all over the world to the MIT campus for eight weeks of intensive study. Course offerings range from space science to space art and law. Some lectures may be open to the public, depending on seat availability. Advance notice is required. Information: (617) 247-1987.

July 16-24, Spaceweek '88, an annual nationwide celebration of the space program. This year's theme, "Space: A Commitment to Our Future," will be marked with public exhibitions, meetings and events. For information on activities in your area, call (713) 480-0007, or write Spaceweek, P.O. Box 58172, Houston, TX 77258.

August, planned launch of space shuttle Discovery from the Kennedy Space Center in Florida. STS-26, the first shuttle flight since January 1986, will carry five astronauts and a NASA relay satellite into orbit, on a mission lasting four days.

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GLOBAL CURRENTS

Australia's Bid for Space Business

From Down Under to Up Yonder

▼ ▼ ▼

By Les Dorr, Jr.

Buckle your breakfast nook straps and imagine yourself aboard the "Orient Express" spaceliner, hurtling toward a landing at the world's busiest commercial spaceport, which, in 2008, is usually referred to simply as "the Cape."

As the Express rolls out after a perfect touchdown, you see the long row of launch complexes dotting the shoreline. What did the brochure say? Sixty percent of the commercial satellites launched during the last five years rode atop rockets fired from these very pads. Quite impressive.

The captain's voice announces the flight time from London: three hours, twenty-eight minutes. "Oh, and mates, enjoy your stay in Queensland and wherever else in Australia you'll be traveling. G'day."

Welcome to the Cape York International Spaceport.

Okay, so where the hell is Cape York? And what does it have to do with launching satellites into orbit? That's exactly what a consortium of Australia's best and brightest high-tech companies intends to tell the rest of the world during the next eighteen months.

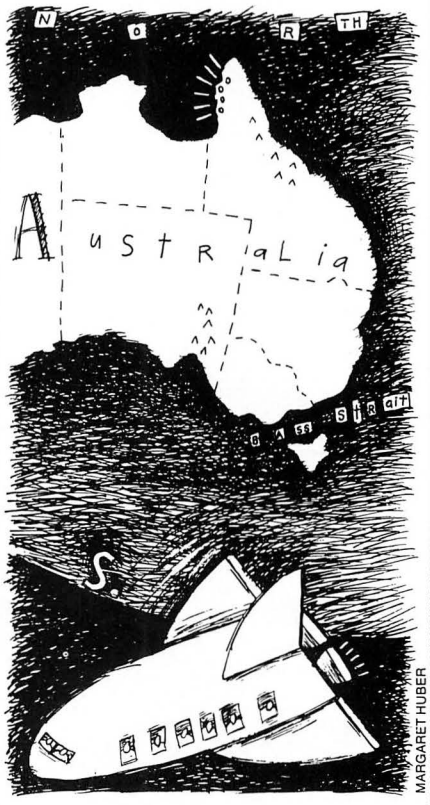
There are currently only two major space centers where commercial launch activity takes place: the NASA and Air Force facilities at Cape Canaveral, Florida and the pads for Europe's Ariane booster in steamy Kourou, French Guiana. Each has its share of operational difficulties.

The weather at Cape Canaveral has a habit of ignoring forecasters' predictions and turning nasty just as rockets reach their final countdowns. Paying customers must choose between an expensive postponement or launching into a thunderstorm. Kourou has the added complication of geographic remoteness; everything associated with an Ariane launch—fuel, rockets, satellites—has to be trucked in from the city of Cayenne down the coast.

In 1986, some of Australia's leading scientists and aerospace executives resolved that there had to be a better way to conduct space business. They approached the government of Queensland, one of the country's seven states, with the set notion of building a privately owned and managed spaceport on the Cape York peninsula, located on Australia's northern coast. The prospect quickly fired the imagination of Sir Sydney Schubert, Queensland's Coordinator General.

"Space is probably going to be the dominant industry of the 21st Century," says Sir Sydney. "We were the third country in the world to launch a rocket into space [in 1957], and we saw the Cape York project would give Australia the opportunity to again take its place in a very dynamic area of technology."

Studies commissioned by Sir Sydney in 1986 and 1987 suggested that a spaceport on Cape York might well lure investors from around the world. The area's proximity to the equator, where the Earth's spin gives a greater boost to a rocket than at higher latitudes, allows a significant increase in payload weight. Weather conditions permit year-round flight opportunities. And space businesses would likely prosper in Australia's stable political and economic climate, enriching the country's technology base in the process.



MARGARET HUBER

The Cape York Space Agency, a group uniting the talents of 64 leading Australian firms, was chosen from among 60 international contenders in February of this year to conduct the legal and environmental studies required before spaceport construction can begin. More important, CYSA pitchmen will tour the world to drum up interest in the commercial possibilities offered by the Cape York project.

"They'll look very closely at the marketing aspects for the next eighteen months to make sure the project is bankable," says Sir Sydney Schubert, "but I'd say there's an 80 percent chance that we'll go ahead."

The Queensland government makes it clear that no group is excluded from participation in the Cape York project, a position that may cause political difficulties down the line. It's no secret that the Soviet Union would like access to an equatorial launch site to boost the payload capacity of its rockets. Immediately after CYSA won the feasibility study, its director flew to Moscow to meet with officials at the Soviet space agency, Glavkosmos. No one seriously suggests that Soviet interest will in and of itself jeopardize the Cape York spaceport, but transfer of sensitive satellite technology could become an issue.

The Australians are in the space business for the long haul. If Cape York proceeds, it's unlikely that the facility would be ready to begin launching until the mid-1990s; it won't be a real factor in the world space market until the millennium.

Yet enthusiasm for space seems almost boundless down under, which gives Jim Mizzell a sense of *deja vu*. Mizzell, an executive of E-Prime Aerospace Corporation in Florida and a veteran of thirty years' service with NASA, spent six weeks in Australia trying to win the Cape York feasibility study for his firm.

"I saw the same enthusiasm at [Cape Canaveral] back in the late 50s and early 60s," says Mizzell. "If Queensland markets Cape York and keeps people aware that 'where there's smoke, there's fire', this thing is definitely feasible." □

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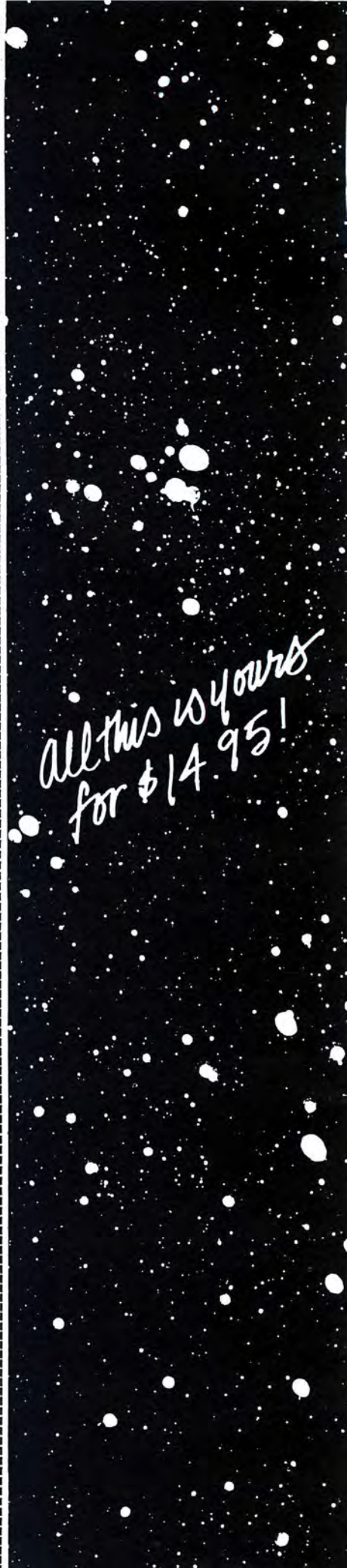

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THE PRIVATE VECTOR

Promises, Promises

Uncle Sam's new space policy may give the little guy a chance.

▼ ▼ ▼

By Melinda Gipson

President Reagan has handed down a new national space policy that promises to open a whole new age for space-faring entrepreneurs. It could be an age where:

- privately built rockets launch skyward from a commercially constructed launch pad on an otherwise deserted stretch of Hawaiian coastline;
- a university consortium strings together used shuttle fuel tanks to house an orbiting space greenhouse or scientific telescopes;
- a private space station rents space to industry and to NASA, tending its "space trailer" from the shuttle.

About those promises. In the early 80's the same administration promised a new age of prosperity to private rocket companies, but it then decreed that the price of a shuttle ride would be sustained so low that it would be impossible to compete with it.

That wasn't the only broken promise. With dirt cheap shuttle rates in effect, some businesses booked shuttle rides for their communication satellites and others built upper stages that would transport those satellites from the shuttle bay into parking orbit over the equator.

One such company, Orbital Sciences Corporation, wagered $70 million on an upper stage which it hoped would serve the commercial communications satellite market.

Then Challenger blew up and the White House kicked most of OSC's potential customers off the shuttle. Commenting on the administration's latest space policy, OSC's Scott Webster says, "The past is a good teacher. I think it teaches any businessman in the space field to be careful because policies change."

Is it sour grapes or healthy skepticism? From the perspective of investors, it's only common sense.

This administration certainly has been on a learning curve since January 28, 1986 when the Challenger exploded. But its assertion that space is now "just another place to do business" is ludicrous. That's like telling Kuwait that the Persian Gulf is just another place to transport oil.

The administration admits that government agencies will be the primary customers of space-related businesses in the private sector. That could be the best news yet for the nation's space industry. Uncle Sam wants industry to design, finance, build and operate major space projects. The government will, in turn buy space services at lower cost, with a wider range of capabilities, without having to foot the bill up front, says Gregg Fawkes, head of the Commerce Department's Office of Commercial Space.

He compared the new policy with buying airline tickets for federal employees who need to travel from one point to another: "We don't go and design and fabricate our own 727 every time we need to get somewhere."

RICK PETERSON

Obviously, there are exceptions to the rule — industry would hardly build and orbit a space telescope simply in the hope the government might use it some day. Many projects might attract commercial customers, however, if the government queued up at the window first.

Fawkes says, "The onus is now on the government manager to solicit industry to find out whether there's any interest in providing what the government needs as a service . . . It shifts the presumption in [space] to what the private sector is able to do."

Realistically, the point at which the private sector would look to the government to finance a project would be when it reaches a cost of $50 million to $100 million, Fawkes said. But, with a definitive government commitment to buy services, even very expensive facilities can be financed privately with every expectation of a return on investment, he said.

Only a somewhat exclusive club of entrepreneurs have their serving windows open now. But the White House is exploring how far the idea could go. If it fosters support now, a few successes could lure in other intrepid businesses. That's the kind of challenge needed to meet the floundering Wall Street climate.

Courtney Stadd, now head of the Transportation Department's Office of Commercial Space Transportation, was once such a pioneer. In the early 80's he headed the Washington office of a small launch company named Starstruck. It went bankrupt only a month after its first successful launch.

Stadd said of the new policy that such a clear set of rules on government conduct in space projects would have been appreciated when he was trying to raise money for his venture. "I remember one Wall Street guy saying to me that, even if I divided by half the profit numbers I represented in my business plan, I'd have a pretty good business. But then he said, 'Call me when the shuttle stops competing for that market.' " With the shuttle out of the market and a government commitment to be a commercial buyer of space services, "I think the little guy has finally got a chance." □

ISAAC ASIMOV

HOSTS A MUSICAL VIDEO VOYAGE IN OUTER SPACE

Voyage To The Outer Planets And Beyond

—Los Angeles Times

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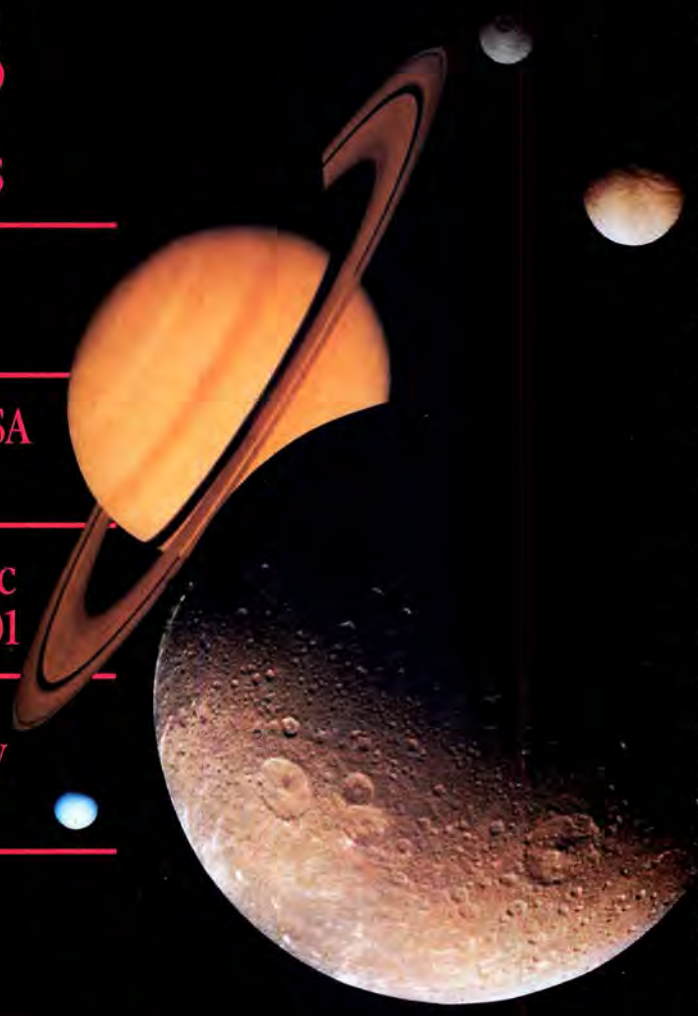

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A VCR Space Adventure

How does it feel to dangle your legs above the Earth, with your back to the Universe?

BY ALCESTIS R. OBERG

SOLO

The first thing you notice is the cold. Gliding away from the shuttle, a solitary human satellite orbiting the Earth, you feel an alien, absolute cold unlike any cold experienced by terrestrials.

"As soon as I got out of the payload bay," astronaut Bruce McCandless said, recalling his historic first flight of the "manned maneuvering unit" (MMU) backpack in 1984, "I was surprised at how very chilly it got. I was shivering at times."

"I was freezing cold," said George "Pinky" Nelson, who used the rocket-powered backpack on the flight following McCandless' to rendezvous with the ailing Solar Max satellite. "The sun was at my back. I had the whole MMU between me and the sun, and the rest of me was pointed at deep space. So that was cold."

Former astronaut (now General) Robert Stewart, McCandless' crewmate on mission 41-B, remembered, "When I went out, I was very warm from working in the bay for quite some time. I could feel the difference, though. It's like laying in bed, being in the bay, where you're shielded on three sides from the cold. And when you leave the bay, it's like somebody pulled the cover off of you. You're not necessarily cold right away, but you can feel the change in temperature."

Only five people in the world—all American astronauts— have experienced firsthand that alien frigid shock. All used the MMU backpack to fly, untethered, from as little as 50 to more than 300 feet from the shuttle, and all can lay claim to the title of "human satellite." (One other astronaut, James "Ox"

S O L O

Van Hoften, tested out the MMU within the confines of the shuttle bay on Nelson's Solar Max flight).

As is typical with NASA technical titles, the name "manned maneuvering unit" doesn't do justice to the reality. "It's like a three-dimensional magic carpet," said former astronaut Joe Allen, who rode the MMU during shuttle flight 51-A in 1984. "It doesn't make much noise when it moves, and it can move you in three dimensions." Astronauts in the MMU can somersault, pirouette, pitch, yaw or roll. They can move up, down, sideways, backward and forward, merely by moving their hand controls slightly. It's a freedom of movement only Superman could conceive of, free of muscle exertion and cardiovascular effort, free of wind and friction. "You use only your fingertips, your head and your eyeballs," said McCandless.

The "magic carpet," like all technical miracles, took over a decade to develop and test. The primary aim of the MMU was to provide astronauts with the ultimate mobility in space, movement that wasn't restricted to the near neighborhood of a spacecraft or limited by the length of an umbilical cord. The primary anxiety, of course, was the horrible specter of the equipment failing and an astronaut being stranded in space. Early on, there was a plan to put the astronaut with the MMU on a long tether, and to reel him in if the backpack failed. But the engineers and astronauts convinced NASA management that the MMU could be tested before it ever left the payload bay. A long tether, they argued, would only complicate mobility and even endanger the astronaut by hampering his movement, wrapping around him or torquing in such a way as to smash him into the orbiter. They preferred to test the MMU for possible problems while it was still in the payload bay. If it did fail later, during a sortie, the orbiter could simply fly over and pick up the stranded astronaut.

It's a freedom of movement only Superman could conceive of, free of muscle exertion and cardiovascular effort, free of wind and friction.

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"Astronauts must look like psychotics or lunatics proposing to fly around out there like that," said McCandless, who was heavily involved in designing the MMU before he flew it in space. "But we asked them to believe us, and they agreed to take the risk." The tether idea was dropped.

The first photos of McCandless and Stewart dangling freely above the Earth, set against the black background of space, have appeared in numerous advertisements, magazine and book covers—an image of perfect human freedom and perfect solitude.

But for McCandless, the inner experience contrasted sharply with the outer appearance. "The communications with the orbiter were so excellent, it was like being around a table together talking."

That flight—the one on which McCandless and his crewmate Bob Stewart tested the MMU for the first time—had been dogged by bad luck. The two satellites that were launched from the shuttle, the Westar and the Palapa, both went off course. A primary experiment to release a large balloon and use the shuttle to retrieve it failed when the balloon was inflated—and blew up. "We were in dread that ground control would say, 'Good grief, these guys are having a bad day. Let's cut our

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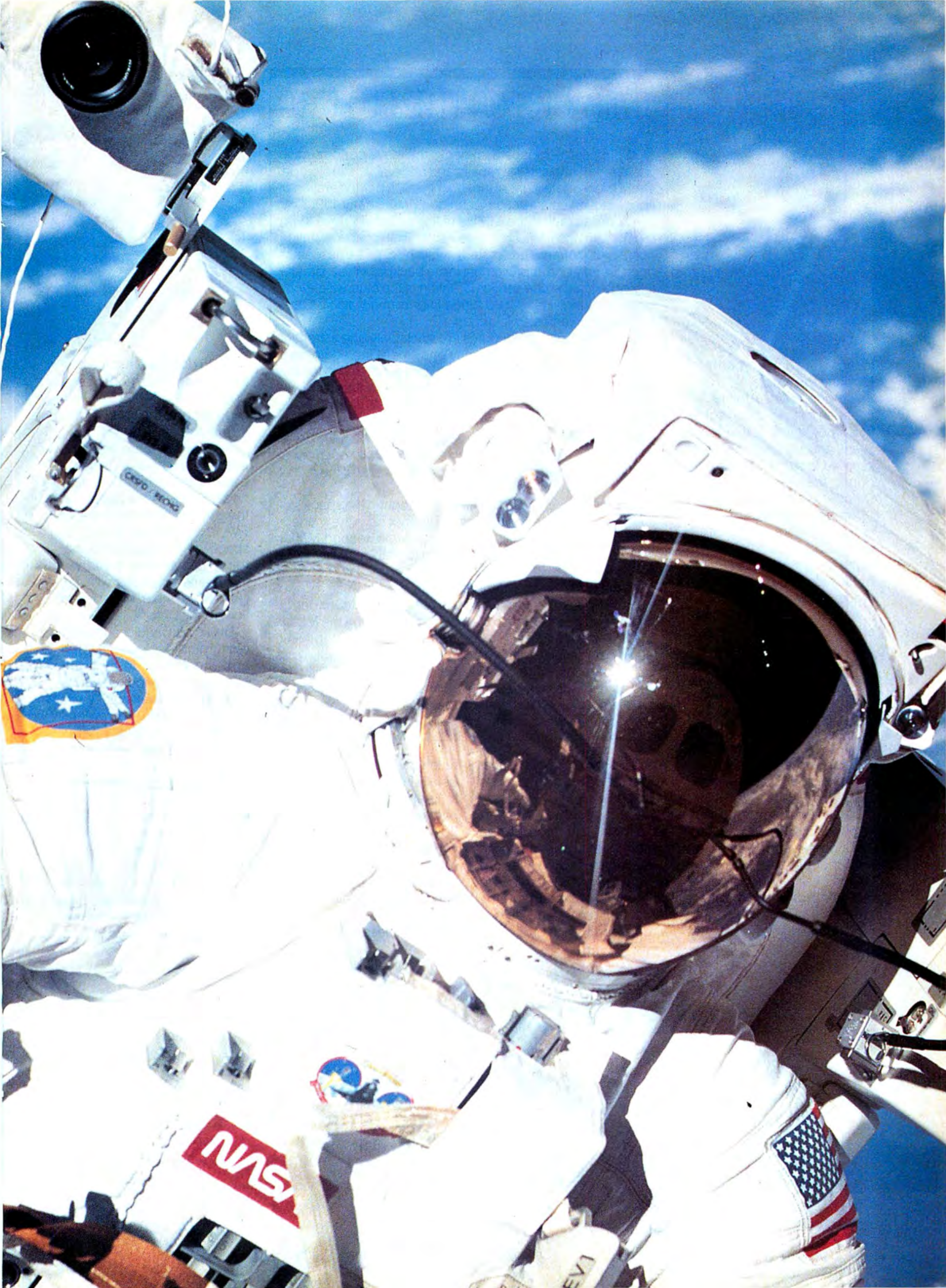


losses and go home,'" McCandless said.

Although McCandless felt confident of the equipment he had worked with for so many years, and although he never seemed to suffer from anxiety during the mission, his commander worried constantly: "[Vance] Brand was concerned that I not wander off too far," said McCandless. "He kept saying that if I didn't come back he'd have to face the media—and my wife!"

Although he had planned on doing a full pirouette to look around, McCandless wound up facing either the orbiter or the Earth's surface the whole time he floated 328 feet from the shuttle. "I had planned on it, but it slipped my mind," he said. "The orbiter was in line of sight the whole time—and I concentrated more on it than I anticipated."

Meanwhile, back in the shuttle bay, Bob Stewart was waging a courageous battle with an imperfect spacesuit. The skullcap helmet that contained his earphones and microphone began to come off, and his feet wouldn't stay in the foot restraints because his spacesuit undergarments were slipping.

"It was terrible," Stewart recalled. "The microphone which was supposed to be around my mouth was up around my eyeballs, so I had to yell to talk. Yelling made my throat dry, but with my helmet almost coming off, I couldn't reach my water. My head was literally frozen inside my helmet to keep from losing my earphones and mikes completely. So there I was with a problem where I couldn't move my head and a problem with my boot that I couldn't investigate because I couldn't move my head."

Nonetheless, Stewart managed to do his work in the payload bay and then don the second onboard MMU to take a glide out over the Earth. "I was afraid the ground [Mission Control] would learn about the problem and make us come back in, so I didn't talk much," he said. "It took the people on the ground almost the entire EVA [extravehicular activity, or spacewalk] to figure out something was wrong, and then they wanted to chatter with me. I kept telling them, I'll just talk to you about it later."

Unlike McCandless, Stewart did turn his back on the Earth and the orbiter to face the blackness of space. "That was very spooky," he said. "I was not prepared for my mental reaction to it. But when I couldn't see the Earth or the orbiter, I spent 10 or 15 seconds like that. And then I got to feeling, 'Boy, it's really lonely out here. Let's turn around and see if the Earth and the orbiter are still there.' It was black, velvety black, and there were no stars because it was daylight. Darkness has been scary since the time we were swinging from trees, and ▷

JETPACKS OF THE FUTURE

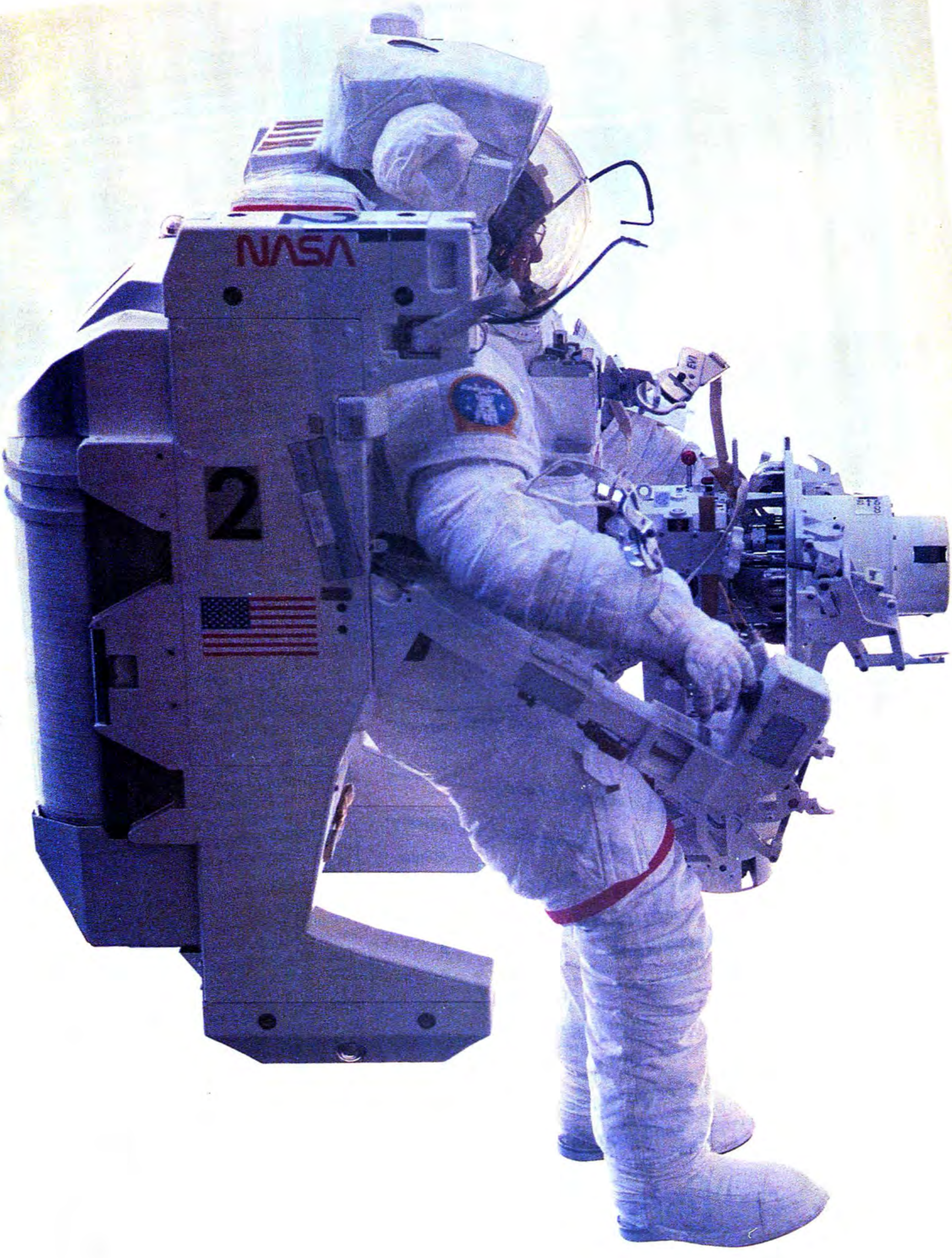
Right now the space backpacks that have performed so flawlessly during satellite repairs and retrievals are in storage. There is one more flight planned for them, a demonstration of space station construction techniques in the early 1990s.

It is possible that the MMUs of the future will have to be modified to accommodate a new spacesuit for space station operations, currently under study within NASA. The astronauts hope for only one improvement in the backpack itself: greater fuel capacity, the one serious limitation of the otherwise excellent equipment. Hand-held range-finders might also be useful if lengthy sorties are planned.

Currently, NASA procedures are strict. Only one astronaut is allowed to use an MMU at any one time. If the equipment malfunctions or fails, the remaining astronaut does not don the additional MMU and go after him. Instead, the orbiter flies over to pick up whoever gets stranded. The rationale is clear: If one MMU failed, the other might have the same problem, and both spacewalkers would be stranded. Also, the shuttle never fires its larger attitude control rockets during MMU operations, to make sure nobody accidentally gets in the way of the rocket plume.

These procedures will have to be rethought in the space station era. Because a space station does not have the maneuverability to pick up a stranded astronaut, a second MMU-equipped astronaut may have to take responsibility for a space rescue.

Some space station planners would prefer to use robotic arms or spacewalkers attached to tethers or exterior handholds to service the space station, instead of using the MMU. But those experienced in the use of the backpack think it would be a serious mistake to neglect the MMU for space station applications. They believe that to throw away a piece of equipment of demonstrated reliability and such great flexibility is just plain crazy. It has earned, they feel, a permanent place in space operations and in space life. □


NASA
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it was sort of a return to that primitive instinct. When I couldn't see anything else, just blackness and me, I got to wanting to feel some contact with something. When I turned around, things were normal again, and I could go about my business."

The 300-foot slow glide back, Stewart recalled, was "fantastic. In the orbiter, the windows are four layers thick and sometimes a little dirty or scratched. But my Lexan helmet was clear Lexan, so I could see more detail, more subtle color variations—it was just a lot crisper view."

However, if one listens to the taped space-to-ground communications during MMU operations, they consist almost entirely of technical chatter. The astronauts are so involved with their work—repairing a satellite, checking out equipment, working through procedures—that there is hardly any time to stop, reflect and absorb the experience. Only rarely do the tapes reveal a breathless moment of wonder punctuating the endless stream of NASA jargon: "I can't believe what it's like out here," Dale Gardner gushed in the middle of some equipment check-out during flight 51-A. "It is magnificent—endlessly fulfilling! Okay, the lights are both out . . ."

Even during MMU operations, when they were literally dangling in space, most of the astronauts can't remember just what part of the planet was below them. "I don't know where I was over the Earth," said Nelson.

"I hadn't thought about where we were," said McCandless, "because what we were doing didn't have much to do with the ground track, our geographic location over the Earth. I happened to look down and was surprised to see Florida—the deep blue of the ocean. The jewel-like colors of the reefs and shallower water around the Bahamas were really beautiful. The Earth was generally beneath my feet, but there was no particular reason for that."

Orientation to the Earth was irrelevant; only objects in the new neighborhood mattered, and the astronauts flew straight lines over short distances the whole time. "I can't imagine that anyone could get disoriented for long," said Stewart. "To not see anything you'd have to be absolutely motionless, looking at a very small section of sky. Even looking directly away from Earth, you have enough light coming from the side that you know where everything is."

However, short-term disorientation is certainly possible. Nelson recalls: "After going round and round with the [Solar Max] satellite a few times, when it came time for me to fly back to the orbiter, I had to be given vectors to point in the right direction. Also, Crip [Commander Robert Crippen] was flying the orbiter to the satellite as I was flying back. That was kind of sporty. I was turning, and the orbiter was turning. That can get a little confusing,

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GROWING PAINS

The National Space Society aims for a new grass-roots coalition: The Crazies and The Establishment.

BY MICHAEL LECCESE

NORA STEWART

NSS staff in the D.C. office.

You could call Lori Garver incredibly devoted to the cause of space exploration. She came to Washington to volunteer for John Glenn's 1984 presidential campaign. She spends evenings studying space policy in a master's program at George Washington University. And when she married in 1986, she deliberately chose a July 20 wedding date: the anniversary of the first footprint on the Moon.

As an administrator of the National Space Society, Garver helps in the care and feeding of 20,000 like-minded space enthusiasts. A few of those members are space professionals, but most are engineers, computer jocks, housewives and "Buck Rogers" types who have long harbored a romantic fascination with space. After Carl Sagan's Planetary Society, the NSS is the second largest of the dozen or so citizens' groups in the "space movement." The number two spot was secured last year, when the National Space Institute and the L5 Society joined their respective memberships to form the new National Space Society.

Courtesy of the nonprofit Society, more than 500 members have been privy to VIP viewings of shuttle launches at the Kennedy Space Center. Many more have eavesdropped on radio communications between shuttle astronauts and Mission Control through NSS's call-in "Dial-a-Shuttle" service.

Lately, in the absence of NASA launches, the Society organized "Mir-Watch" groups to gaze at the new Soviet space station. Hundreds have called in to ask when they might get a five-minute glimpse of the orbiting spacecraft. By feeding the caller's geographical location into a computer, the Society can deduce prime times for its members to track Mir's path through the morning or evening skies.

Legitimate thrills for any space buff. The Society's real mission, though, is not to entertain, but to convince Americans they need a bolstered federal space program as well as private ventures into the cosmos. They communicate that message through a monthly magazine, *Space World,* regional meetings, an annual Space Development Conference and a taped space news hotline that draws about 200 phone calls a week.

At times the Society perceives a hostile political climate for its message. Says chairman Gordon Woodcock: "I suspect most people now think of the U.S. civilian space program as pork barrel politics and TV entertainment. That's how it gets treated in Congress, except in subcommittees concerned with NASA."

The Society also prods NASA to be more adventurous. According to Woodcock, "Our space program . . . has no goals, no direction, no real mission. Since Apollo, NASA has been building 'infras-

tructure.' If that word isn't enough to turn you off, consider that the shuttle and the space station are means, not ends . . . solutions looking for problems."

The Society's staff of nine battles such recreant attitudes from the International Space Center in Washington, D.C. Don't be fooled by the high-tech name: The center can be found in a brick, bay-fronted Capitol Hill townhouse filled with cast-iron fireplaces. Two-thirds of the Society's $750,000 annual budget is derived from the annual membership dues of $30. The rest comes from an Aerospace Industries Advisory Council representing Boeing, Rockwell, McDonnell Douglas and five other blue-chip aerospace companies.

The building also houses Spacecause, a recently formed lobbying group headed by McDonnell Douglas astronaut Charlie Walker (who once made a point of bringing his Society membership card on a space shuttle). Down the hall you find SpacePAC, a political action committee that plans to funnel funds from 3,000 contributors to the campaign chests of presidential candidates who support space exploration. To comply with federal regulations governing nonprofits, Spacecause and SpacePAC are kept rigidly separate from the Society. But Garver says they are "part of the same family."

Increasingly, the Society encourages its members not only to ponder the space program as it is today, but to consider the possibilities.

Their promotional material draws heavily on science fiction art—a Michael Whelan painting of a space-suited child making sand-castles on the lunar surface, for example. One brochure states: "We're out to make dreams reality. . . . Our frontier lies in space. Our destiny lies in the stars. It no longer lies on the Earth."

For some in this organization, conjuring up images of people playing among the stars would have seemed much too wild-eyed even a year ago. But today's Society represents a melding of two distinctly different groups with a common bond: ten years of struggle to attract large memberships and score political points.

The old National Space Institute grew out of an effort by rocket scientist Wernher von Braun to create a cosmic variation on the National Geographic Society. In the mid-1970s he secured private funding and brought aboard support from celebrities like Jacques Cousteau and Bob Hope. Prospects seemed strong for 100,000 members and 100 corporate supporters within three years.

For some in this organization, conjuring up images of people playing among the stars would have seemed much too wild-eyed even a year ago.

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As Garver puts it, "von Braun had the ability to inspire the masses."

Then von Braun died at age 65 in 1977. The Cousteaus, Bob Hopes and John Denvers never really got a chance to stump for the cause. Some of them dropped out of sight. Attracting members proved costly. NSI poured $900,000 into one effort, but never drew more than 20,000 supporters. By 1986, that number had dwindled to 8,000. Wrote space movement historian Michael A.G. Michaud, "The NSI may not have lived up to everyone's expectations, but it did provide the first gathering place at the national level for citizens interested in space."

About the same time von Braun gave birth to NSI, Gerard K. O'Neill, a Princeton physics professor, was gaining notoriety for a "big idea": the colonization of space. Specifically, he proposed artificial colonies of 10,000 people, and even picked out orbital "lots" to subdivide: two libration points where the gravitational pulls of the Earth and Moon are balanced, known in coordinate terms as L4 and L5.

O'Neill's idea proved striking to 129 computer whizzes and engineering students who attended the second Princeton Conference on Space Manufacturing Facilities in 1975. Almost spontaneously the group formed the L5 Society, a mostly male cadre who believed they would soon live in the space colonies envisioned by O'Neill.

Their motto: "L5 in '95."

Although some of O'Neill's notions intrigued the NASA/Congressional establishment, other supporters included LSD guru Timothy Leary, Sci-Fi freaks, space groupies and radical environmentalists who believed in depopulating the Earth. (This was to O'Neill's dismay, according to Michaud.) Among their mottos: "Declare the Earth a wilderness area" and "Decentralize — get off the planet." Their membership was once described as "5 percent Democrat, 5 percent Republican and 90 percent anarchist."

Though the L5 grew to 9,000 members in 70 chapters, and was even credited with defeating an international treaty it saw as hostile to private enterprise in space, it never succeeded in convincing industry or the government to commit funds to build space colonies. After 1980, the group eased into a more moderate stance and attracted respectable scientists and other space experts to its board. But when L5 shifted emphasis to other issues, membership declined to about 5,000.

With both of their memberships in decline, it seemed that NSI and L5 had much to gain from a merger. The L5ers would bring their enthusiasm, their well-organized chapters and their "phone tree" of 18,000 people willing to lobby their representatives to support space initiatives. NSI contributed respectability and access to the stars—not the ones in the Solar System, but celebrities like Telly Savalas to sit on its board.

In 1987 L5 and NSI officials signed the merger papers, and three paid members of the L5 staff moved from Tucson, Arizona to Washington. The two groups joined under the direction of NSI executive director Glen P. Wilson, a veteran Senate staff member and former NASA official who says "the present organization is in a position to become truly effective."

Not everyone agrees. "We suffer from an identity crisis," says Greg Barr, the Society's deputy director and a former L5 offi-

cial. "Are we L5 or are we NSI? The Society is very much in a period of reassessment. What it really needs is something the business community calls strategic planning . . . to try to get the board and staff to agree on a set of principles. If we don't do that, the organization won't be effective."

In Barr's opinion, this hasn't happened. The Society lacks policy stands on crucial issues, from commercial space incentives to exploration of other planets. "If someone comes to us and says, 'What's your position on Mars?', we kind of look at each other and say, 'Well, what's our position on Mars?'"

One issue on which the Society did take a stand, of sorts, was the Strategic Defense Initiative. Its board voted to stay neutral on "Star Wars" and to focus Society efforts on civilian space programs.

But Lori Garver says the organization is simply going through a pre-launch shakedown. A total of forty board members, two chairmen and four vice-presidents survived the merger. They will be pared by attrition, Garver says: "Right now it's unruly."

Space historian Michaud offers a gloomier view: "I think that [L5 and NSI] are an uneasy mix, and I suspect they'll lose members." He thinks citizens might be better served by more specialized groups. "The day of the universal citizens' space group may be over."

But NASA seems to be in NSS's corner. That bodes well for the types of cooperative programs and perks that attract new members—the box seats for shuttle launches, for example. Says Alan Ladwig, who turned his early involvement with a grass-roots space group into a career at NASA (he is currently director of special projects in the new Office of Exploration), the Society "has been a very positive contributor to the space discussion." Ladwig is particularly impressed by the "Mir-Watch" campaign. "It makes people think, 'There goes that space station again. Where's ours?" □

Michael Leccese is a freelance writer in Washington, D.C.

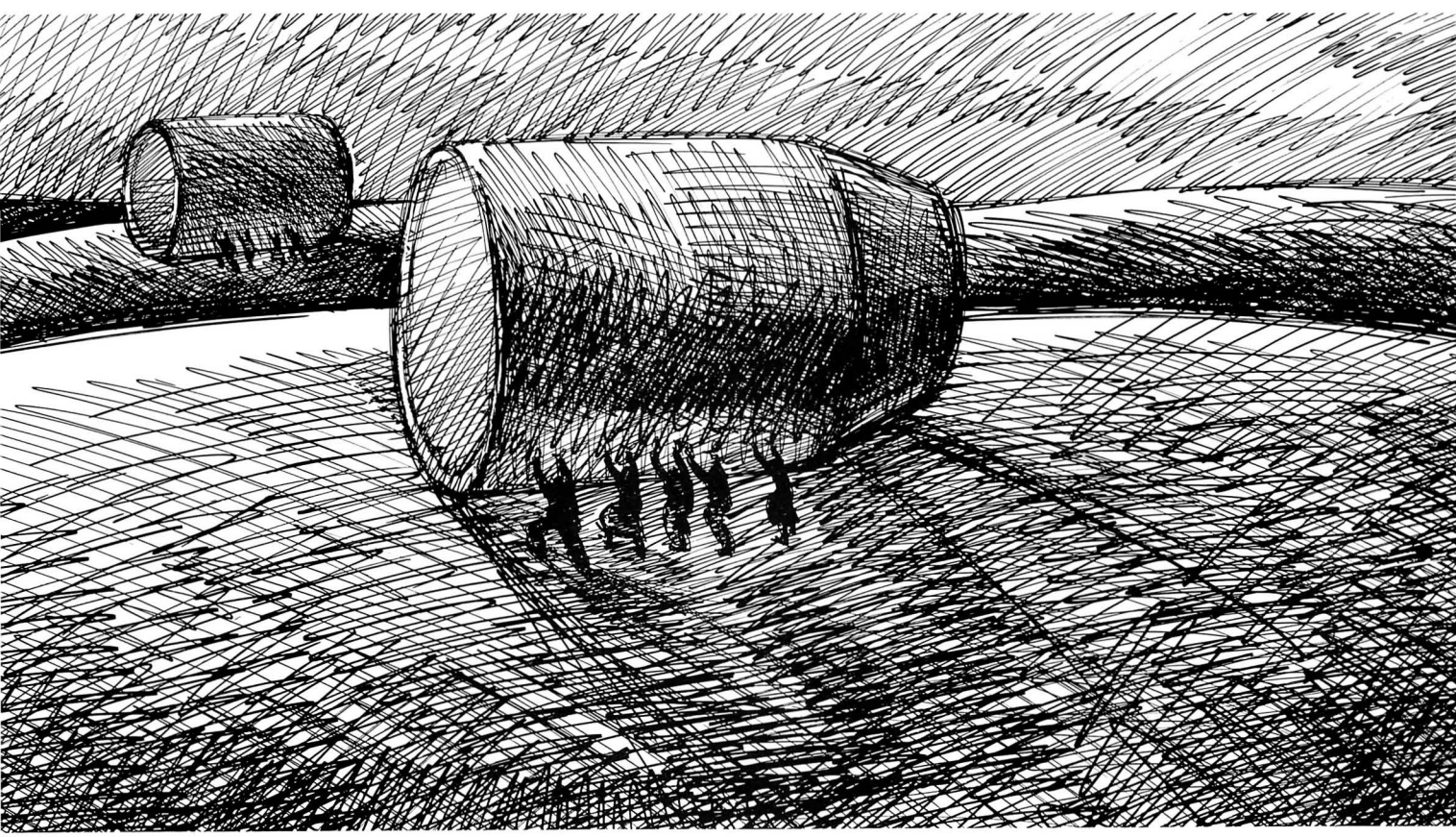
Joining Up

The National Space Society's promotional literature proclaims it as "the largest organization of its kind in the world." This presumably means that, while the 100,000 member Planetary Society conducts most of its activity at the Olympian level of Sagan and Spielberg, the NSS's thing is grass-roots participation.

With the merger, the new Society inherited the old L5 chapter system, a loose confederation of nearly 100 smaller clubs in more than thirty states and a few foreign countries. One of the compromises of the merger was that the chapters could retain their original names, as long as they attached "a chapter of the National Space Society" to their title. The list is therefore something of a hodgepodge: there's the "Milwaukee Lunar Reclamation Society," the "ExoCalifornia L5" in Big Sur, and an Australian "Southern Cross L5" in both Sydney and Adelaide.

The chapters range from a few people meeting once a month to discuss the state of the space program to the larger groups that arrange film showings, tours and public lectures by NASA officials, or hold larger regional meetings where space freaks can share their enthusiasm with each other and with the public.

To find out about chapters in your area write The National Space Society, 922 Pennsylvania Ave., S.E., Washington, D.C. 20003, or call (202) 543-1900. □



STAN OLSON

Bob Truax once headed up major national launch programs. Now he's working on bigger things out of his house.

BY ROBERT G. NICHOLS

THE FIVE ROCKET GARAGE

Starting a company in a garage and nurturing it into a thriving business is an American dream that very often becomes a profitable reality. That's what happened to Steve Jobs and Steve Wozniak. They started out building and selling computers to fellow hobbyists, and within a few years found themselves with the multi-billion dollar Apple Computer Company.

For Bob Truax, the dream is to get his rocket company, Truax Engineering, off the ground. And yes, he is working out of his garage. "But that's no problem," he quips, "because I have a five car garage."

Despite his self-effacing humor, Bob Truax is deadly serious when it comes to Project Private Enterprise, which aims to come up with a space transportation system that is cheaper than the space shuttle or any other launch vehicle.

At first glance this might seem like the ultimate fantasy of a hopeless space enthusiast. Developing launch vehicles is an expensive undertaking that can quickly consume the resources of a nation or a multi-billion dollar corporation. It's not generally attempted by a man with a vision, "forty volunteers," and intermittent funding.

Robert C. Truax, however, is not a man to be taken lightly. A retired Navy captain, he spent most of his adult life working on rockets, and is considered one of the important pioneers in the field. Almost from the day he graduated from Annapolis in 1939, Truax took a leading role in Navy rocket programs, including what eventually became the Polaris missile project. While on loan to the Air Force, Truax headed up the then-secret Atlas and Thor rocket programs. After retiring from the military, Truax worked for Aerojet General Corporation and designed(on paper) a heavy lift launch vehicle called the Sea Dragon. If anyone can run a rocket development program, it's Bob Truax.

While working on government-funded rocket projects, Truax had the opportunity to analyze the cost factors behind the development of launch vehicles. His conclusions were a major force behind the creation of Project Private Enterprise.

Among the things Truax learned is that size has little effect on the final cost of the launch vehicle. For example, while working for the Air Force, he supervised the development of the Thor and Agena rocket boosters. Though the Thor was ten times larger than the Agena, their final costs were about the same, Truax said. Several years later he saw the same thing while working for Aerojet, prime contractor for the Titan 1 rocket motors. The engines were similar except that the second stage motors were smaller and produced half the thrust of the first stage motors. Nonetheless, they cost about the same to produce. "Here you had the same time frame for development, the same design, and the same propellant," Truax explained. "Yet the big ones cost less than the little ones. That's ridiculous, isn't it?"

Truax had discovered what we all find out when we have work done on our cars: labor costs more than materials. And when you're talking about space flights, labor translates into development costs. Most of the money is spent on designing, testing, and developing a piece of hardware. Building the hardware accounts for only a small part of the overall bill.

Since hardware development really drives the cost of the vehicle, Truax concluded that there are two things you do to bring the cost down: make the parts big and make as few as possible. That was the key to the Sea Dragon design that Truax came up with during his stint with Aerojet, and that's the key to his Project Private Enterprise launch vehicles.

Another, more radical approach to reducing costs is to launch from the water. When you launch a rocket from the water you don't have to worry about building expensive launch support structures; the water supports the vehicle until lift-off. It's not cost-effective to launch small and mid-size rockets from the water, Truax explains. Water launch becomes economical only when you're using boosters the size of NASA's old Saturn 1 rocket or larger.

The aerospace industry's reluctance to accept the idea of water launches is probably born of "visions of water dripping onto the electronics," Truax speculates. But, he says,tests conducted in the 60s show that nothing but the outside of the

SCOT SOTHERN

Bob Traux at his launch console: Scrounging for cash, scavenging for parts.

booster gets wet. What's more, if the rockets are properly designed they can be reused with minimum refurbishment.

Of course, no matter how good your ideas are, you just can't go out and start building "big, simple, reusable" rocket boosters. That's why Project Private Enterprise is divided into three phases; the smaller first steps will prove the ideas that will attract the investors necessary for the larger boosters. First, a scaled down booster will be tested on several sub-orbital flights. Phase two is the construction of a fully reusable orbital booster which will be marketed commercially. The final phase of Truax's ambitious dream is to build a titanic vehicle that will dwarf NASA's retired Saturn 5.

Truax is currently in the middle of phase one, building and testing small test vehicles called Enterprise. Because they measure only 25 feet in length and 25 inches in diameter, these boosters are being built in Truax's garage.

Test firings have already been completed. Mounted on a portable test stand, the vehicles were brought to the desert and fired in a captive position, that is, the vehicle never left the ground. "During the first go around we had some problems," Truax admitted. "But after a redesign, we had five successful firings. It looks like the propulsion problems are by and large behind us," he concluded.

With the static tests behind him, Truax is in the process of building three boosters for sub-orbital tests. Burning liquid oxygen and kerosene, the rocket motors will produce 4,000 pounds of thrust, more than enough to loft the 3,000 pound rocket to the fringes of space, but not enough to reach orbit.

Plans call for several test flights from one of several possible launch sites on the California coast. These will be launched from land-based platforms; Traux is leaving the water launches for phase two. The rockets will accelerate to about 2,700 miles per hour, ascend to an altitude of 62 miles and fall into the Pacific ocean 10 miles down range. The entire booster will be retrieved, refurbished, and launched again. By conducting several such test flights, Truax hopes to gather enough data to prove his boosters can withstand an ocean recovery and be reused with only minor refurbishment. "Our goal," Truax boasts, "is to launch them repeatedly without any refurbishment other than filling them with propellant."

After he successfully demonstrates the test vehicle, Truax intends to put a man aboard the rocket and send him on a suborbital jaunt into space. He has even selected an "astronaut" — a volunteer named Fell Peters—for the first manned voyage of the Enterprise. Truax admits the purpose of this stunt is money; he hopes to sell the television rights for the launch and recovery of his astronaut. Worldwide television broadcast of the first manned launch aboard his Enterprise launch vehicle could net Truax Engineering over $10 million, he estimates. That money will go a long way toward funding the next phase of the project.

"We are about halfway through the construction of the new boosters," Truax said. The only thing holding him back is lack of funding, a problem that plagues all high-risk startup ventures. Truax will need another million dollars before he can launch the first vehicle. To date, about $1 million has been spent on the project. About one quarter of that came out of his own pocket while another quarter came from Chicago real estate investors. The other half was provided by miscellaneous investors, people who shared Truax's dream and vision.

To keep costs down, Truax has become a first class scavenger. The Enterprise launch vehicles are being constructed from equipment the Air Force and NASA were going to throw away or auction off. The engines for his test vehicle are old, though unused, thrusters designed for Atlas boosters. "We bought 20 of them for $120 apiece," Truax said with a laugh. The fuel regulator valves were designed for the Agena upper stage but were easily modi-

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An international band of future-minded architects is working on plans for the first lunar shelters.

DIGGING IN ON THE MOON

What's new in lunar architecture in 2001 may very well be what's *old*.

Depending on who you talk to, the first permanent homes on the Moon could be built of recycled shuttle or space station parts, made-on-the-Moon stucco, or a kind of indoor balloon on a flight to nowhere.

The pioneers of the American West wintered in lean-to's fashioned from the Conestogas that had brought them into the wilderness. Nebraska sodbusters channelled under the prairie soil to put a roof over their heads. In the opinion of many lunar architects, the first Moon dwellers may also be living in their vehicles or burrowing into homes dug from virgin lunar "topsoil."

Some of these visionary planners are even leapfrogging ahead to look at living quarters and factories for the second and third waves of Moonbase inhabitants. These follow-on groups are likely to begin the exploitation process in earnest, establishing mines and small factories on the Moon. Still later arrivals would move deeper into the wilderness to map and explore, leading the way for the "citizen" colonists, who would arrive to practice a trade, build a community, set up a business or raise a family on the Moon.

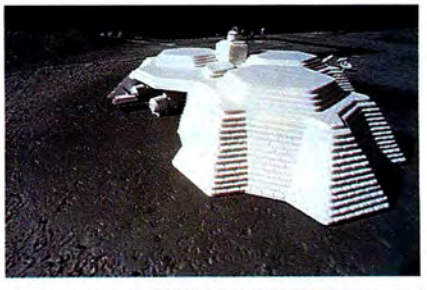
Some of what's being developed in lunar architecture is brand new and truly otherworldly. Much, though, is reassuringly familiar. And a few ideas are ancient, with roots deep in the past.

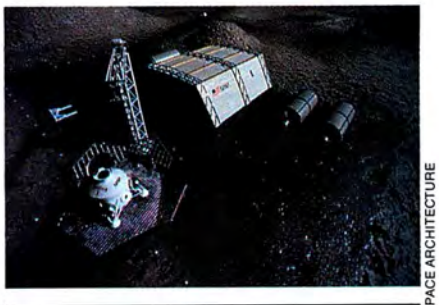
"If anyone shows you a real Moonbase, it's probably going to look like dirt mounds with antennas and radiators on top." Greg Maryniak of Princeton University's Space Studies Institute takes a decidedly pragmatic viewpoint. "A lot of these bases will be like oil rigs. You don't build an oil rig to live on, though you do try to make them as livable as possible in an otherwise grim environment."

The Princeton group is studying a number of nuts-and-bolts ideas for Moon dwellings, on their way to becoming a sort of lunar 3M Company: Moon Mining and Manufacturing. They hope to learn how structural materials can be manufactured on the Moon

BY MAURA J. MACKOWSKI

NASA

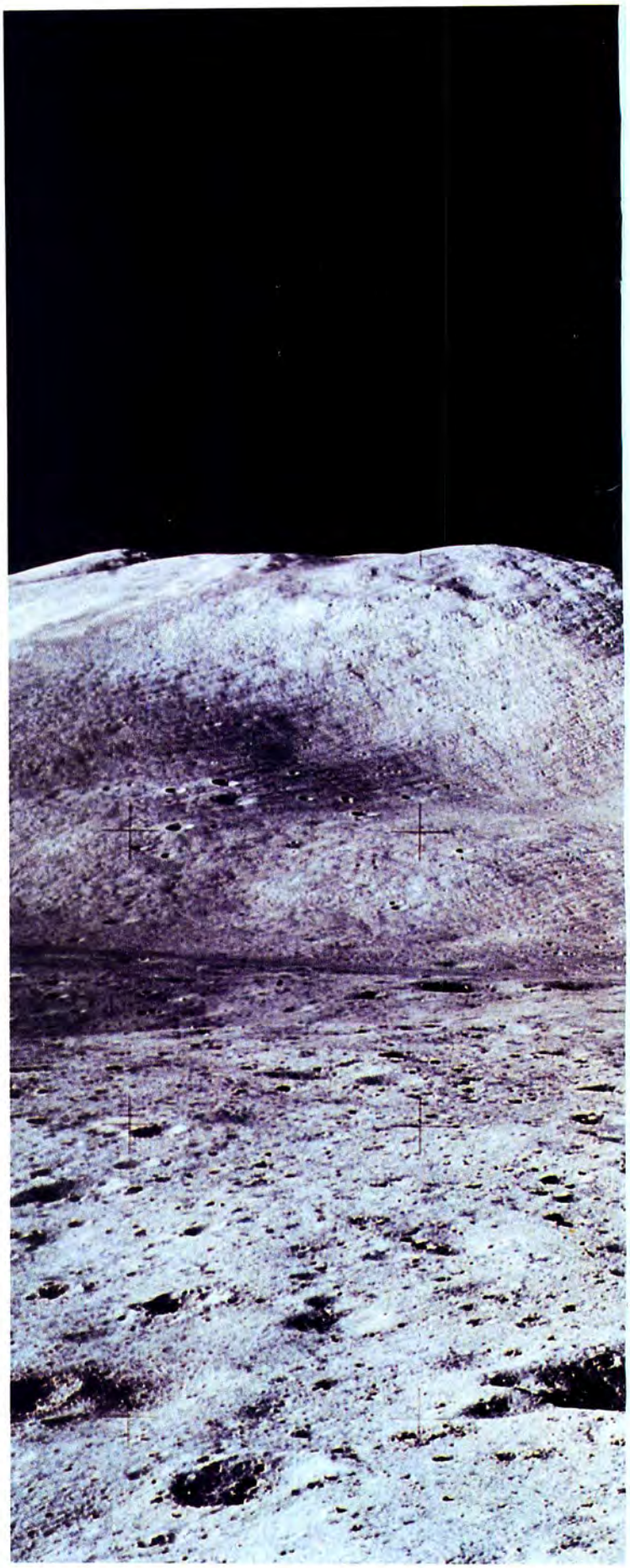




SASAKAWA INTERNATIONAL CENTER FOR SPACE ARCHITECTURE

Designs for lunar living: (from top) an early scientific and construction outpost: two views of the Lunar Ecosystem and Architectural Prototype (LEAP), an advanced base for up to 150 people; a lunar launch pad; and Lunar Hab, an inflatable module with an interior structure for creating separate rooms. All concepts are from the Sasakawa International Center for Space Architecture.

COURTESY OF YOUSEF HIJAZI



Saudi architect Yousef Hijazi (at left, above) wants to transport his designs for erectable structures to the Moon (opposite page).

and to demonstrate how lunar soil, which contains significant amounts of nickel and iron, can be separated to produce machine components. Another goal is to learn how glass in lunar soil can be made into fibers to manufacture strong yet lightweight composite materials.

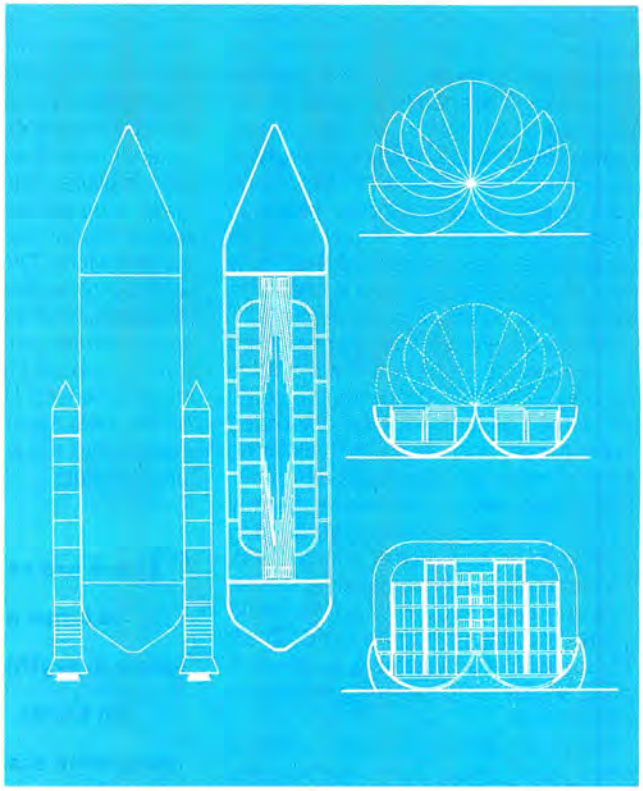
Architects and engineers who plan to use native lunar materials to build a Moonbase claim economy and simplicity as their main motivators. It certainly isn't beauty, since the lunar palette spans only a narrow range of color from gray to beige.

Peter Land of the Illinois Institute of Technology is an architect and engineer by training, whose previous experience is in experimental building technology. After doing work for the United Nations on earthquake-proofing buildings, he went on in the early 1980s to develop building designs for the surface of the Moon. His designs call for extensive use of lunar regolith, primarily for radiation shielding. That word — regolith — pops up quite a bit in lunar base discussions. It translates roughly from the Greek as "loose, unconsolidated material that rests on the solid rock of the earth's crust." In other words, it's whatever soil, rock and sand the lunar base settlers happen to find lying around.

Radiation and thermal shielding are critical for a lunar base. The Moon has some regions in permanent shadow and extreme cold, while others are in blazing sunlight and scorching heat. Solar flares would almost certainly mean lethal exposure to gamma radiation for unprotected humans.

One of Land's building designs resembles a Quonset hut with low arches made of molded regolith, covering either a lattice structure or inflatable supports. The pressurized interior, which Land terms a "pneumatic envelope," is made of Kevlar or some similar thin plastic material, enabling lunar base workers to go without space suits.

Out in California, David Nixon of Future Systems Consultants, Inc. is working on structural shielding methods. Nixon proposes a 6-7 foot thick layer of material that could absorb deadly radia-



An erectable lunar building could be folded inside a cylinder, which would crack open like an eggshell on the lunar surface.

tion before it reached the occupants of the base.

His idea is for a very lightweight superstructure, like a net or a tent, "a base on which to deposit the six or seven feet of lunar soil — sort of a bunker-like thing," he explains. Lunar soil, with its high calcium oxide content, would be made into 21st century lunar cement, to be poured or blown over a support structure, much as stucco homes in the American Southwest are made of concrete blown over a two-by-four frame hung with chicken wire and styrofoam.

Future Systems is also looking at inflatable structures. Although Nixon says it's too early to get into specifics, he believes that "a tremendous amount of research is needed to make [a structure] that will stay inflated even if a meteorite comes buzzing through."

Nixon says that many visionaries, sensing an opportunity for the commercialization of their lunar habitat ideas, will want to keep a closed mouth now that the United States has begun thinking seriously about returning to the Moon. "A lot of companies that think they have good ideas will want to hold on until they have their patents," he commented. "People do pinch ideas in this business, like they do in any other."

The fact that lunar architecture is slightly off the beaten path appeals strongly to Nixon's sense of artistic adventure. "This is a fascinating field, offering a whole range of challenges," he says. "It's a paradox; the key challenge is how you make these small, confining quarters habitable and productive. At the same time, you [the architect] are working with microgravity, which is very liberating. The challenge is to combine the two, to construct something free-form and relaxed."

Some lunar architects envision a sort of trailer park on the Moon, where pre-fabricated habitats launched from Earth and softlanded on the lunar surface would house the first settlers. One variation on this idea calls for the Earth-launched and Moonbuilt philosophies to merge, with pre-fab dwellings shielded by lunar dirt.

Guillermo Trotti is one-half of a Houston-based architectural

design team specializing in space-related projects that has achieved international recognition for its work. The Argentine native is also associate director of the Sasakawa International Center for Space Architecture (SICSA) at the University of Houston, and his partner, Larry Bell, is one of the founders of Space Industries, Inc. in Houston. It's a measure of how far we've come in space exploration that Trotti, now in his late 30s, has been able to spend his entire career on space projects.

Bell & Trotti are proposing pressurized structures very much like the modules planned for NASA's space station of the 1990s. The buildings would be soft-landed on the Moon, and would most likely be made of metal or composite materials. Radiation protection and some thermal insulation would be provided by burying the modules in 10 to 16 feet of lunar sand. The architects also have looked at the use of pneumatic structures, which would inflate and then become rigid. Their "Lunar Hab" is an inflatable structure in which an interior trusswork is erected to create rooms.

"We are integrators, involved in a little bit of everything," says Trotti. "We're in the education business also, getting people capable of supporting industry." He characterizes his firm as "a think tank," and intends to keep it that way. Bell and Trotti now have 12 employees, but anticipate doubling the firm's size within another year or so, largely due to their association with Boeing and its space station work.

When comparing terrestrial architecture with designing for the lunar environment, Trotti states, "The key differences are gravity, the lack of atmosphere, radiation and temperature differences. These are major, major differences."

Designing lunar home interiors presents much less of a problem for architects than do radiation shielding and thermal protection. Because the Moon has some gravity — one-sixth of what we experience here on Earth — habitat space is used much as it would be in a terrestrial building. But, says Trotti, "There are certain advantages, since everything is lighter than on Earth. You can stay away from stairways and make rooms bigger because people can run farther and jump higher." Construction should be easier in some respects, Trotti says, because "fewer people can do a lot more [on the Moon], and you wouldn't need heavy cranes."

Most lunar design work has fallen to small companies such as Bell & Trotti and Future Systems Consultants. But at least one large aerospace firm, Astronautics Corporation of America, is willing to state for the record that they are working on their own plans for the Moon.

Dr. Eric Rice, director of the Madison, Wisconsin firm's technology center, is looking at Moonbase designs and lunar mining, as well as "closed" ecological systems, robotics and propulsion. Rice says that the 1500-employee company is "spending some of our own money and doing some work under contract."

Lunar base designers live, for the most part, in places where there are cultivated fields, abundant water and a rich variety of natural resources, places very different from the Moon. They rely on their imaginations to project what it would be like to exist in a harsh, hostile environment where no accommodations or sustenance are to be found. Yousef Hijazi needs no such imaginative leap. He lives in Jedda, Saudi Arabia, near the city of Mecca, where he goes about the business of designing lunar habitats.

"There are certain advantages to lunar architecture, since everything is lighter than on Earth. You can stay away from stairways and make rooms bigger because people can run farther and jump higher."

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Dry and hostile in its climate, Mecca is visited annually by two million Moslems, for whom a hajj to the Mohammaden shrine is the holiest of religious experiences. Many pilgrims come on foot, often with nowhere to stay, trusting that Allah will provide. Mecca's leaders have taken some of that task on themselves, however, and have commissioned studies to provide temporary housing for the pilgrims. Hijazi's designs for collapsible structures, inspired in part by traditional Saudi tent dwellings, have been put to this use. That set him to speculating what other environments might have a need for fast, simply erected housing.

"What I am doing is completely prefabricated on Earth," the Saudi architect explains, outlining his design for lunar habitat modules. "The structure is self-adjusting to the site and has its own system for protection from radiation." The entire structure contains "a complex of four five-story buildings with 70-80 rooms, including some self-contained laboratory facilities, offices, and living units."

Viewed in cross-section, Hijazi describes his habitat as "split into two halves that open like a book and raise up to form four floors." Radiation and thermal protection are provided by spacing between the floors, and by the walls of the pneumatic tubes.

Lunar base design is going on in other countries as well, including Japan, where several Tokyo-based firms are spending money to support advanced work on lunar architectural design. Shimizu Construction Company is putting some of its $6 billion in annual revenues behind a number of space endeavors: Earth-based, orbital, lunar and planetary. The firm recently reported creation of a Space Project office.

Kyoichi Kuriki is a Tokyo professor working with Obiyashi Corporation, another Japanese construction firm, in studying lunar base concepts. He is looking in particular at the human parameters for the lunar outpost — the minimum number of astronauts needed to establish a base. This involves a number of factors, including the maintenance requirements of the structure, the efficiency of the food recycling process, and the cost of resupply from Earth. "The chief technology issue is to determine the dimensions of the base and the size of the crew," Kuriki says, adding that five to ten looks like the right number of people to start with.

In Germany, Hermann Heinz-Koelle, one of Wernher von Braun's rocket scientists and a professor at the Technical University of Berlin, has formed a team to prepare mathematical models related to the establishment of lunar industry. "We're studying alternatives of how to get there, and then how quickly you want to build up, so you can estimate what kind of costs will be needed and when the paybacks will come," he explains. "How much food is needed? How much will one hour of human labor cost? How much is a ticket to the Moon and back?"

Jouko Raitala of the University of Oulu in Oulu, Finland is studying the lunar crust, its makeup and how it shifts — basic science that should be of great value to lunar engineers. The Soviets are reported to be interested in studying lunar bases as well, although there are virtually no details available in the West on specific plans and designs.

Back in the U.S., Greg Maryniak of the Space Studies Institute stresses the importance of tackling the Moon base design problem one step at a time, rather than worrying now about what is very far downfield. "That's like the Europeans of the year 1500 saying, 'Let's figure out city planning for America.'"

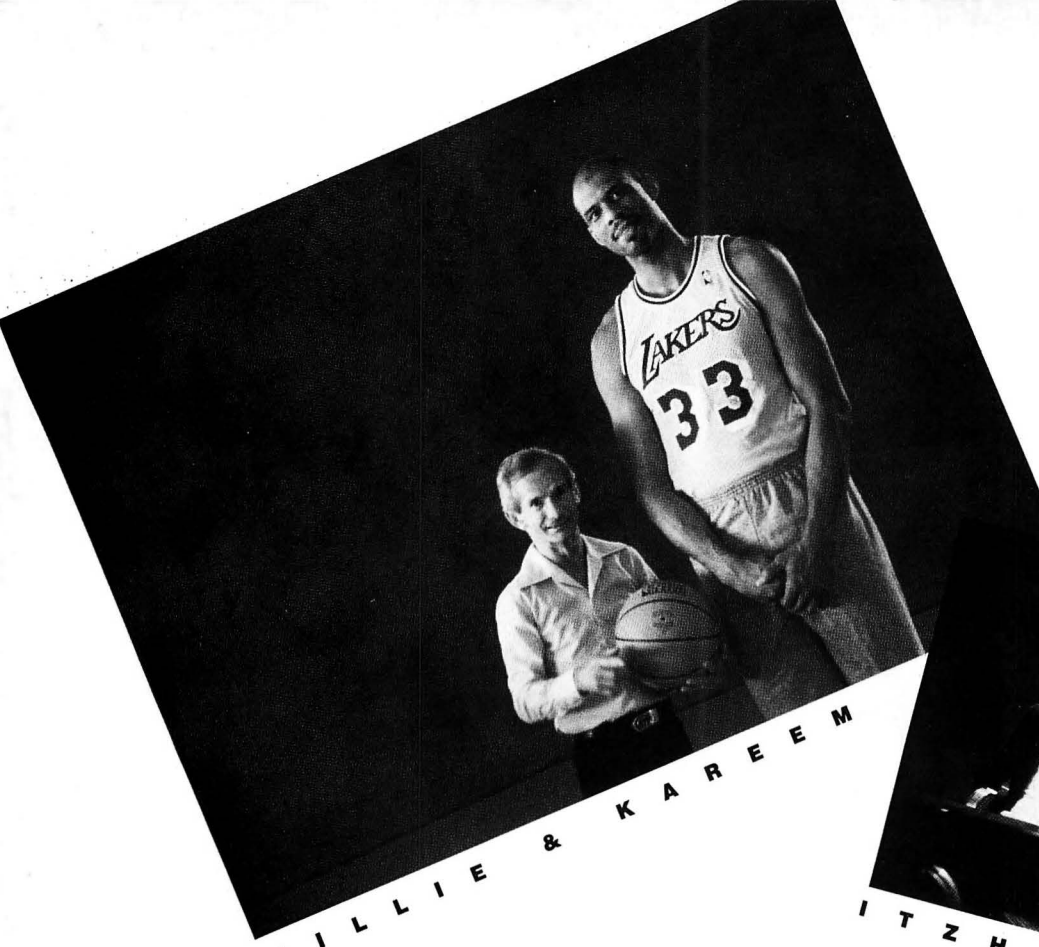
What the first, second or hundredth lunar base will look like is anyone's guess at this point. But it's a safe assumption that architects will draw upon lunar resources, so that their designs, ultimately, will look like nothing on Earth. □

Maura Mackowski is a freelance writer in Florissant, Missouri.

THE STARS COME OUT FOR SPACE

Celebrities take to the TV airwaves to plug the benefits of space technology.

BY TONY REICHHARDT ▷



WILLIE & KAREEM

ITZHAK & RAY

Have you seen them yet? Ray Charles jamming with Itzhak Perlman? Gloria Steinem trading quips with Charlton Heston? Willie Nelson and Frank Sinatra, arms around each other, joshing and teasing like bowling buddies?

You expect this kind of behavior during fund-raising telethons or at the Academy Awards ceremony, not in TV commercials promoting, of all things, the space program.

But that's where a group of about two dozen political, showbiz and sports personalities have been appearing lately, singing the praises of NASA technology. The public service spots, sponsored by the Advertising Council for the non-profit U.S. Space Foundation, debuted on the air last fall, and will run into next year.

The ad campaign was the brainchild of Douglas Morrow, a Hollywood screenwriter, producer and space aficionado who couldn't bear to wallow in the post-Challenger doldrums without doing something to help the cause. So Morrow called up some of his cronies from the film business, including Ronald Reagan, and got the ball rolling for this "little thing" — as Sinatra would put it — on space technology. It is, without doubt, the most high-powered public relations effort in the history of the space program.

The cast of characters, paired up in 18 different TV commercials, includes four presidents (Nixon, Ford, Carter and Reagan) as well as past and present hopefuls (Barry Goldwater and Jesse Jackson). One spot matches a Democrat and a Republican (Tip O'Neill and William Buckley), while another teams a half-pint (Willie Shoemaker) with a seven-footer (Kareem Abdul-Jabbar). Other unlikely partners are Whoopi Goldberg and Helen Hayes, Tom Selleck and Carol Burnett, Chuck Yeager and John Madden, and — all by his venerable self — Gregory Peck.

Matching up the different odd couples was Morrow's idea. A little entertainment value, he figured, would sugar-coat the otherwise straight message about how space technology contributes down-to-Earth spinoffs. So Jabbar and Shoemaker, who barely fit on the screen together, tell us about scratch-resistant glasses derived from space helmet visors. Hayes and Goldberg ("the old guard and the new wave," jokes Whoopi) marvel at a car for handicapped drivers, while Steinem and Heston engage in some feminist vs. he-man bantering during their lesson on the benefits of satellite imagery.

The spots, produced by the Campbell-Ewald (now Lintus USA) ad agency, are crisply paced, and the patter is snappy:

Sinatra: Willie, it's obvious we don't share the same tailor. What do you call that [headband]?

Nelson: I call it my way, Francis.

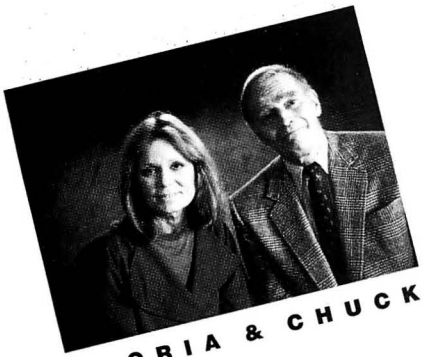
Sinatra: Touché.

Nelson: Right on.

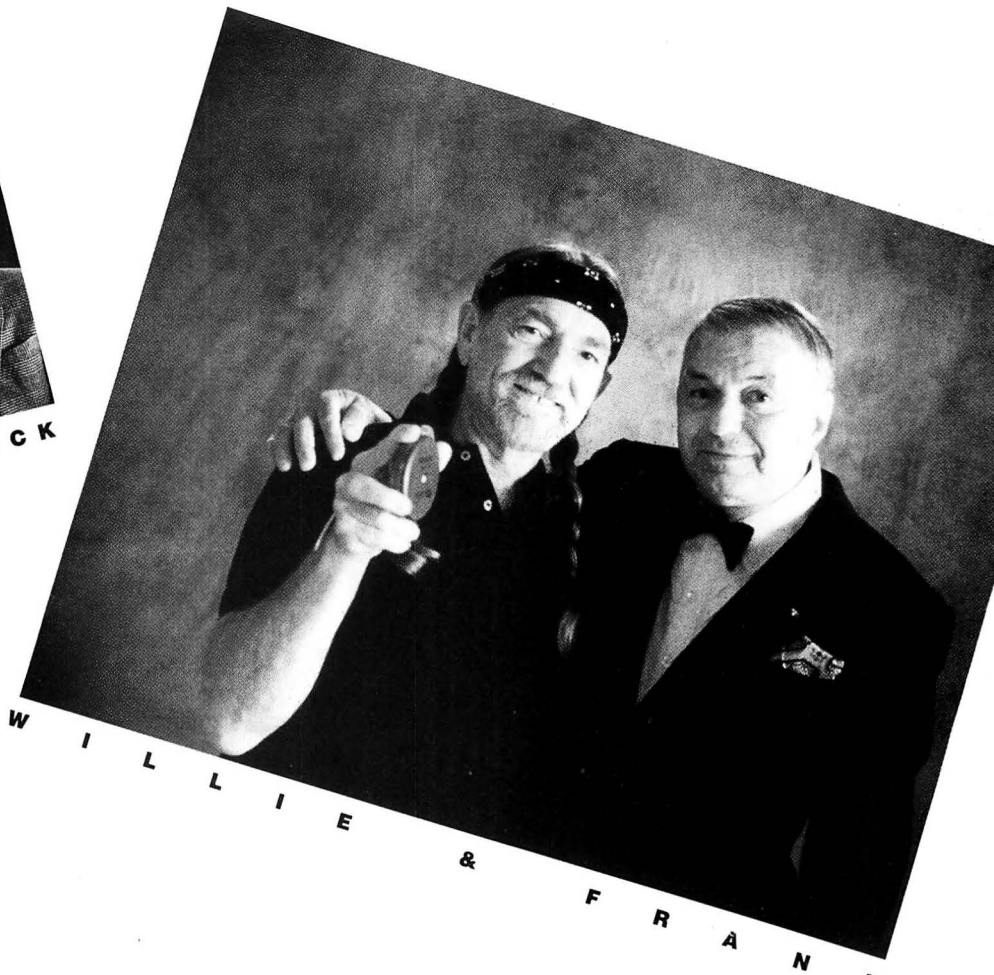
Sinatra: But we do share the same feelings about space technology, don't we? . . .

And so it goes. At the end of each 30-second spot comes the tag line "Space technology: This is what's in it for you," along with a toll-free number displayed on the screen so viewers can call to receive a free booklet on spinoffs from the U.S. Space Foundation.

Even though it all seems like fun, Morrow says that gathering the glittery ones was no easy task. In fact, he says, "It was a hell of a hard job to get them all together."



GLORIA & CHUCK



WILLIE & FRANK

Without doubt, it's the most high-powered public relations effort in the history of the space program.

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The Oscar-winning screenwriter (for his 1949 film biography of baseball player Monty Stratton) called friends like Sinatra himself. Others were contacted through their agents.

Reagan even helped to recruit a few, including Tip O'Neill and Gloria Steinem. Even though, according to Morrow, "I don't think the President's done one single thing she agrees with," Steinem said yes when Reagan phoned.

Few of the stars had any prior interest in space, Morrow admits, and some — he won't say who — even had to be talked into it. But all, he claims, were "boggled" by the different space spinoffs — reading devices for the blind, lasers for artery repair, a method for turning sewage into drinking water and the like.

Once filming began, "everybody had a great time," according to John Howe of Campbell-Ewald. On other productions, Howe has had to suffer the kinds of temperamental "talents" who demand that all the brown M & M's be removed from their candy trays. Here, he says, "They all showed up and seemed to be in great moods, like they wanted to be here."

The commercials were shot in Los Angeles, Washington, San Francisco and New York, wherever and whenever the odd couples' schedules intersected for an hour or two. The money for logistics and production, which Morrow says ran into seven figures, was donated by aerospace companies. The stars and the ad agency gave their time for free.

Since the first commercials began airing last October, the response has been better than anyone had hoped. Public service announcements sponsored by the Ad Council are normally plugged into a station's schedule wherever there is a hole, or when commercial time is cheapest. "The Ad Council thought we'd be lucky to air six or eight times," says Morrow. The celebrity spots were aired 57 times in the first month of release, including some prime time exposure.

The campaign may not create the tidal wave of space boosterism some would hope for, but in the first few months the U.S. Space Foundation was taking calls as fast as volunteers could answer the phone. By February, the Colorado Springs educational institution had logged some 16,000 requests for information, a healthy turnout for any non-profit campaign.

And while TV commercials are not usually considered great art, the taping sessions did produce at least one gem. In New York, Charles and Perlman met for the first time. While the film crews were setting up, the musicians broke into an impromptu version of "Georgia on My Mind," and a quick cameraman caught most of it on tape — a two-minute outtake that, even though it ended up on the cutting room floor, made all the trouble worth it. □

JAPAN'S JEM OF AN IDEA

The Japanese Experiment Module may be the toast of the international space station.

BY GARY STEPHENSON AND GREG FREIHERR

Sometime in the mid-1990s, a space-suited astronaut crew will put the last finishing touch to NASA's permanent space station orbiting 220 miles overhead. On that day champagne glasses around the world will be raised to the most complex space construction project ever attempted. If current plans hold, the United States, Canada, and a dozen nations of the European Space Agency will all be part of the celebration—along with one newcomer to the world of manned spaceflight, Japan.

Since signing on to the international space station project in 1985, the Japanese have steadily gone about designing what may turn out to be the most versatile part of the whole facility. In fact, the Japanese Experiment Module could become the "JEM" in this orbital crown—one that may prepare Japan to outshine the rest of the world in the next century's race for space.

NASDA

Japan's astronauts-in-training: (l. to r.) Mamoru Mohri, Chiaki Naito and Takao Doi.

One of four cylindrical "modules" clustered at the center of the football field-sized station (which will house six to eight people when fully assembled), the JEM will be unlike any other component. In a single compact package, it will combine the best elements of the whole—a closed, manned laboratory workshop plus an open platform for exposing experiments to space.

It also will be Japan's first critical step away from purely scientific and applied programs. "We have not had manned systems experience," says Takehiko Kato, director of the Houston office of Japan's National Space Development Agency (NASDA). "This is a starting point."

Two Japanese astronauts will work in and outside the three-part JEM laboratory. The largest section is a cylindrical command center 33 feet long and 13 feet in diameter. Mounted on top of that will be a pressurized storage compartment about half as large. The third section is a feature none of the other three modules have—an exposed pallet that extends more than 30 feet in front, like a porch hanging out into space.

Inside the JEM command center, scientist/astronauts will conduct a wide range of materials science investigations based on the results of Japanese shuttle experiments to be flown in the next few years. Among the likely areas of interest are the growth of silicon and other crystals, the behavior of molten metals and glass in weightlessness and in-space testing of new high-temperature superconductors.

"Unless you make something and check if it works in microgravity, you don't know what kinds of things you can make [in space] and how to use them," says Kato. "Once you establish those procedures, maybe you can make them on the ground."

By conducting experiments on cells, animals, plants, and the astronauts themselves, the Japanese hope to learn how living creatures respond to microgravity, how space radiation affects biological tissue and even what foods might be grown in orbit.

Some of the planned experiments will be uniquely Japanese, reflecting a culture molded by centuries of island living. According to Tsuguo Tadakawa, director of NASDA's Washington office, one study will focus on the adaptation of fish to weightlessness. Another will grow seaweed in orbit.

From consoles in the command center, Japanese astronauts will command a robot manipulator arm much like the current shuttle's. Looking through portholes or at video screens will allow the astronauts to monitor the arm's motion. Besides helping to assemble the pieces of the JEM, the arm will be used to install huge structures such as antennas. With a reach of over 30 feet, the arm and its "two-finger" attachment will also play a critical role in operating and replacing experiments on the outside "porch."

This extraterrestrial workbench will be densely packed with experiments exposed to the high vacuum and low temperature of space. Some will involve material processing techniques too dangerous to be performed inside the module. Others will train telescopes at astronomical targets or point sensors down at the Earth. If any of these experiments needs the human touch, spacesuited astronauts will be able to slip out of an airlock that leads directly onto the exposed pallet.

The JEM's upper storage compartment will essentially be an orbital attic—a storage locker for instruments, bottled

gases for experiments, and biological specimens. In the event of a disaster, it would become a lifeboat with enough air and power to buy the two-person crew an extra three hours before they could be rescued or evacuated to one of the American or European modules.

JEM will be the working quarters for the two Japanese astronauts. The core base of the space station will be their home for sleeping, eating and relaxing, a sort of high-up Hyatt Hotel. Current plans call for the JEM to be delivered into orbit and attached to the station on two consecutive shuttle flights in 1996, late in the overall assembly sequence.

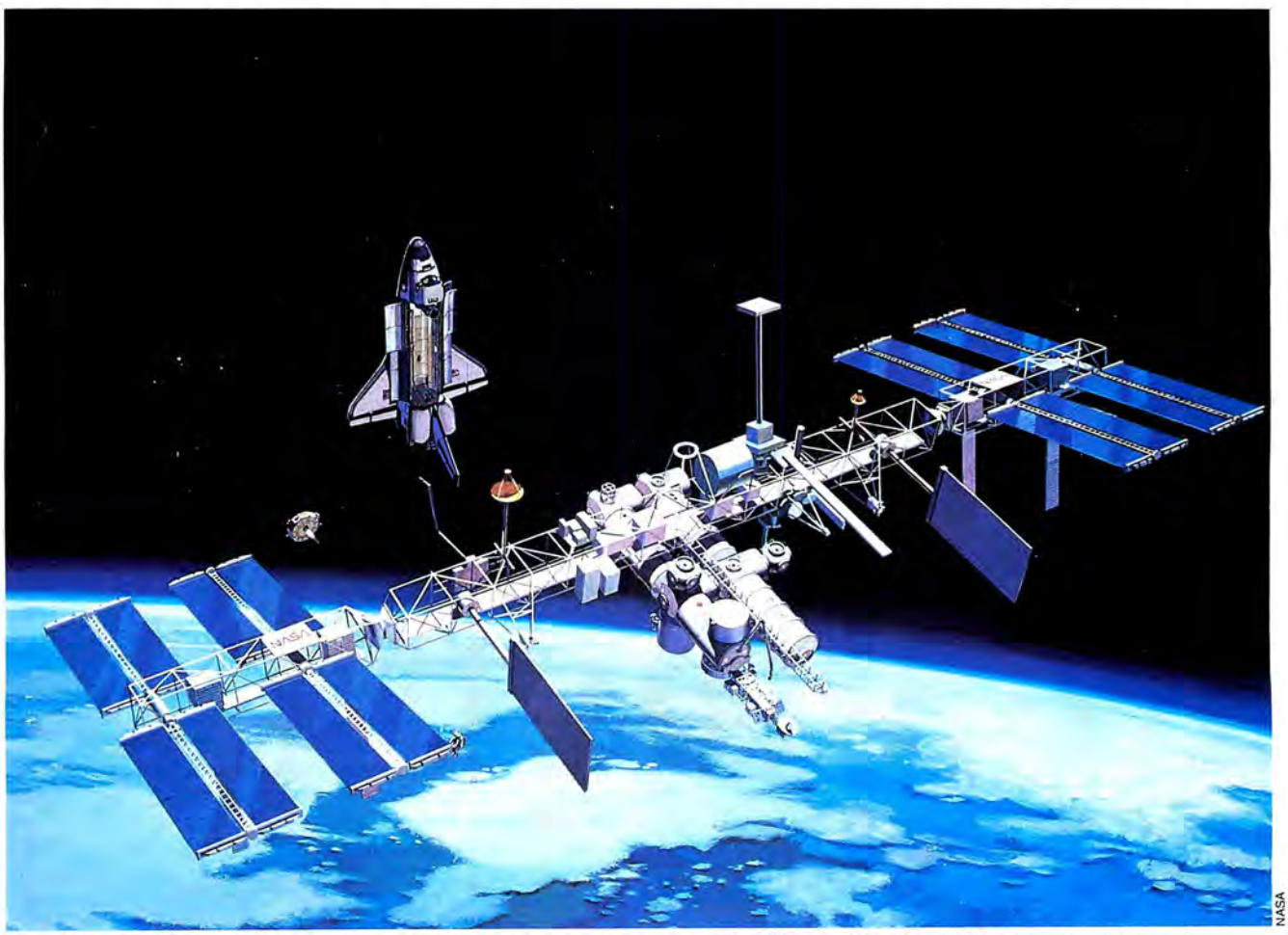
Some space observers think the Japanese are getting an extraordinarily good deal with their first venture in human spaceflight. "They are getting into space for a relatively modest investment," says Frank B. McDonald, NASA's chief scientist. "I'd take it myself if I could buy a laboratory in space for a few billion dollars, something that is going to cost the United States around 30 billion dollars after all the numbers are put in. That is one of the great bargains of all time."

McDonald also thinks the joint venture is a good idea. "I think if they don't get in bed with us, they could turn around and get the same deal from the U.S.S.R.," he says. "You don't want to force them in that direction."

According to Jerry Grey, director of science and technology policy for the American Institute of Aeronautics and Astronautics, a joint venture with Japan promises technological rewards. "The evidence shows that joint endeavors are healthy.... If our own research investment is as strong as the Japanese, we will stay ahead easily. The problem is that they maintain a level of commitment for research and we do not."

Communication satellite technology—a major focus of research on the JEM—is one area in which the Japanese have jumped ahead of the United States, says Grey, who points to Japan's impressive Engineering Test Satellite program as an example. According to Grey, Japan is now orbiting communication satellites operating at a level of sophistication that American satellites will not approach until 1992 at the earliest.

"The U.S. has always led this field technically, but during the last five or six years our lack of advanced research has allowed the Japanese to move ahead," he says. "They are staking out the technology for the next generation."



NASA

The international space station will have four modules attached to a supporting "keel," with solar panels at each end to supply electrical power. The JEM is at bottom left center.

Some of the planned experiments will be uniquely Japanese, reflecting a culture molded by centuries of island living.

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Through a concentrated program of testing and development, the Japanese hope to launch a revolution in communications, developing new concepts such as an international mobile communications system that would allow personal communication by satellite. The new technology would also bring new standards of economics and quality to broadcast services.

Anyone who doubts the potential of the Japanese space program need only look at what the island nation has accomplished in less than three decades. The Japanese have not one, but two space ports perched on islands in the Pacific Ocean—and they have developed a knack for building rockets. After years of relying on liquid-fuel rocket technology licensed from the makers of the American Delta vehicle, Japan is now going it alone in the development of propulsion systems for the H-I and H-2 rockets (see accompanying story).

Jerry Grey describes the Japanese space effort with respect, admiration and a touch of apprehension about what it means for the United States in the coming century.

"When the Japanese make a commitment to something, they are willing to look at the very long term," Grey says. "This first entry into manned flight is not the end for them; it's just the beginning."

Frank McDonald of NASA thinks it's too early to sound the alarms of Japanese "competitiveness" in space. "I think you will see a steadily increasing, not a dominant role for the Japanese," he says. "If you look at the size of the Japanese program, it is running around 10 percent of the U.S. program. They're not spending very much money. It is a very modest program."

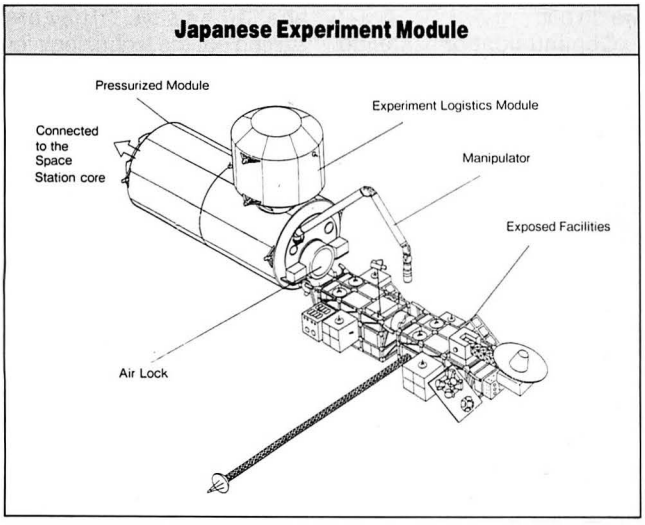
Nevertheless, Japanese leaders in government, industry, and academia issued a report last year that called for Japanese space dominance in the 21st century. Serving on the Space Activities Commission were the chiefs of NASDA and Japan's Institute of Space and Astronautical Science (ISAS)—the two agencies charged by the Japanese government with defining and putting into action Japan's space program. Also on the commission were experts in domestic and international studies, communications, and space technology.

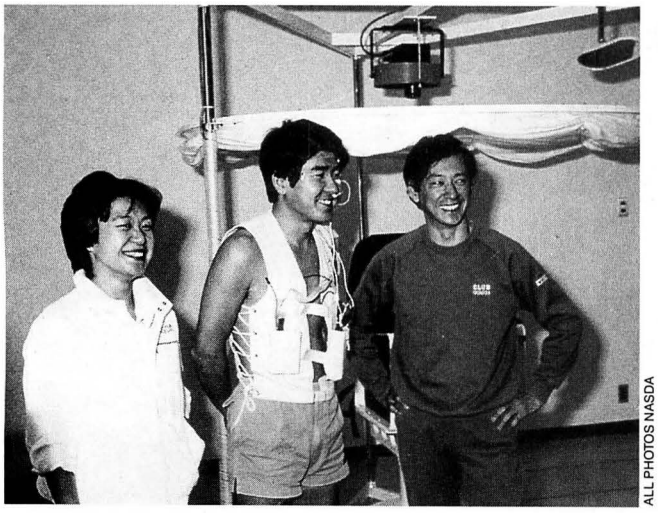
They chose as their goals for the late 1990s and early 21st century to make space industries self-supporting and to begin exploring the Moon and planets with visiting unmanned spacecraft. Where does JEM fit in with this grand scheme?

As the 21st century approaches, the report states, JEM will lead to an independent Japanese space station, a nearby orbiting experimental platform, and manned orbiting factories. An aerospace plane will shuttle astronauts directly from runways on the ground to low orbits. Free-flying robots called orbital servicing vehicles will take supplies to and from manned outposts. Orbital transfer vehicles—sophisticated space ferries—will retrieve damaged satellites for servicing at the space station and boost refurbished ones back into their orbits. Meteorological, communication and navigation satellites will form a network for gathering and transmitting information never before seen, while probes explore the Solar System and beyond.

According to the Japanese Space Activities Commission, "the scientific exploration of outer space. . .will lead to a new era in human culture." If JEM is only the beginning, and if all goes according to the plan, much of that culture will be Japanese. □

Gary Stephenson and Greg Freiherr are freelance writers based in Washington, D.C.





ALL PHOTOS NASDA

The Japanese Experiment Module will allow astronauts to conduct experiments inside and outside the station.

The Toyota of Launchers

It may be the import vehicle of the 1990s — for reaching Earth orbit.

Although Japan's H-2 rocket has not yet lifted off the drawing board, it shows every indication of becoming the premier choice for putting mid-sized cargoes into space in the next decade. With its two large solid-fuel boosters strapped to a sophisticated three-stage liquid-fueled rocket, the H-2, which is scheduled to debut in 1992, should be able to hurl 4,400 pounds into the geostationary orbit favored for communication satellites — slightly more than the capacity of the U.S. Air Force's own mid-size, the Titan 34-D.

"The H-2 is an excellent piece of engineering," says Jerry Grey, director of science

and technology policy for the American Institute of Aeronautics and Astronautics. Although he believes the rocket's chances of flying by 1992 are slim, he says "It is as good or better than anything we currently have. . . . We have some research engines that are of that level, but they aren't incorporated into a vehicle."

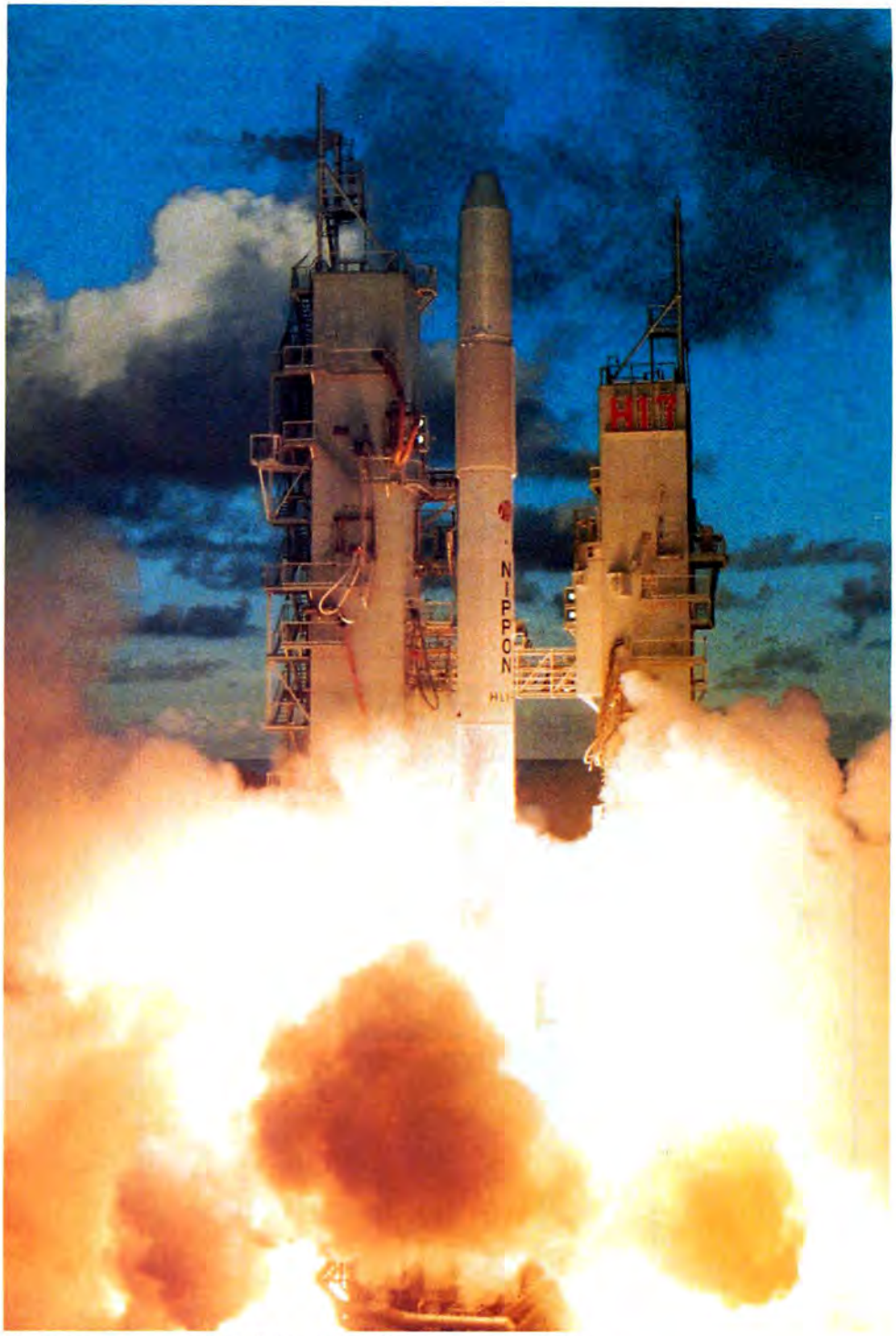
Japan's accomplishments are all the more impressive considering that its space program has been active for only about 20 years.

"The whole thing started with us buying the know-how, the licenses," says Takehiko Kato, director of the Houston office of Japan's National Space Development Agency (NASDA). "We did not want to be dependent on whoever makes [the rockets], because if the price goes up and they know we don't have the technology, then we are at their mercy. If we do it ourselves, we can do it much cheaper."

In 1986 the H-1 rocket that is currently Japan's top of the line completed its second successful test flight, nosing through the skies over the Tanegashima Space Center, located on the island of the same name, (where launches are restricted to two 45-day seasons out of deference to commercial fisherman).

After the H-1 kicked a half-ton communications satellite into orbit, the McDonnell-Douglas Company, maker of the Delta rocket and license holder for the technology used on the H-I's first stage, immediately proposed a joint venture to commercialize the new Japanese rocket. Company officials also expressed interest in importing the technology for the H-1's second stage, which was designed entirely in Japan.

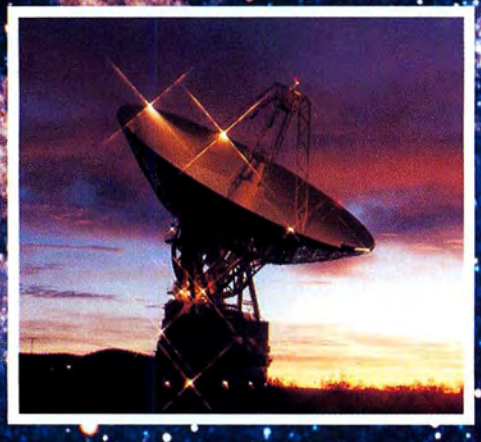
But negotiations ended, Kato says, because "Japan will not export any weapon or anything used for the military." The Delta rocket on which the Japanese stage was to be mounted has been used recently in test flights of technology developed for the Strategic Defense Initiative.



The H-1, forerunner of Japan's homegrown H-2 rocket of the 1990s.

The fact is that the Japanese no longer need American companies. The H-1 and H-2 rockets are expected to extend their reach into space well beyond the turn of the century. That reach may be extended further by the addition of Japan's HOPE space plane (H-2 Orbiting Plane), a small reusable mini-shuttle. Unlike the U.S. shuttle, HOPE will be for cargo only, piloted by remote control and onboard computers. NASDA also is considering the development of a special launcher for small payloads, a move that could help Japan capture both ends of the market.

Until now, technology licensing agreements and Japan's own needs for access to space have prevented the Japanese from marketing their launch services to other nations. When the totally Japanese-designed and -built H-2 rolls out to the launch pad in the early 1990s, however, it could add a world-class contender to the space launch marketplace.



IS ANYBODY LISTENING?

How a dedicated band of NASA SETI-ologists began their search for intelligent life in Washington.

BY LINDA BILLINGS

Columbus Day, 1992

The unveiling ceremony opens with a salute to "extraterrestrials" in our own solar system. The giant dish antenna locks onto radio signals transmitted by robot probes at ever greater distances from Earth. The first is a resource satellite circling only a few hundred miles overhead. Next is a spacecraft in orbit around Mars, followed by Voyager 2 somewhere out beyond Neptune, then Pioneer 10, about four billion miles from home.

Finally, the radio receiver turns toward a pre-selected region of the sky and begins to listen. The most comprehensive SETI (Search for Extraterrestrial Intelligence) project in history is underway. In the next six years, it will comb the radio universe, trying to answer the question: Are we alone?

ALL PHOTOS: NASA

October 1987

At the biggest international space conference of the year, NASA Administrator James Fletcher stunned his audience by announcing that the most important space project the United States could undertake over the next couple of decades would be a search for extraterrestrial intelligence. Delegates to the International Astronautical Federation Congress could understand why Fletcher chose not to talk about prickly subjects such as the shuttle recovery and the beleaguered space station program. But SETI? Even SETI enthusiasts weren't sure if they should be happy about Fletcher's announcement. What a great speech, they thought, but what the hell does it mean?

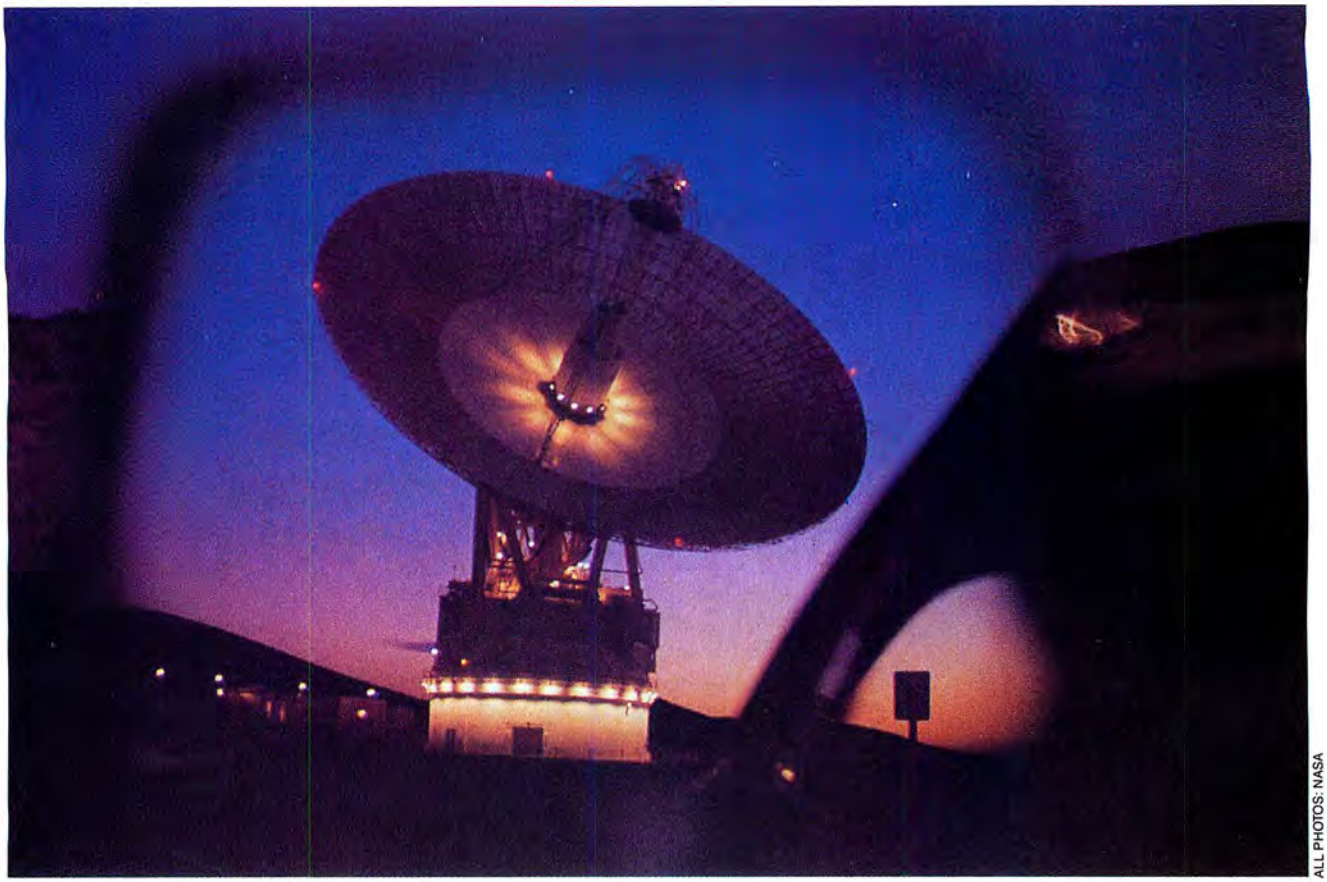
"In order to fully understand our origins and destiny," Fletcher told the dumfounded delegates, "it is necessary to know whether we are alone." If and when humans make contact with other intelligent beings, he said, "communication could lead to the equivalent of another intellectual renaissance, and maybe even could change our perception of our Earth instantly from one of competing states and super-states to a single, precious home for the human family."

Yow! Here was an undiluted dose of the new-millennium philosophy that tends to creep into talk about SETI, the kind of it-might-change-the-world thinking that is hard to resist in this age of nuclear anxiety. But as Fletcher spoke, NASA's SETI program manager, Lynn Griffiths, was back at headquarters in Washington struggling with reality. She was trying to map a plan for a 10-year SETI program without knowing how much money she would have to spend.

Griffiths had seen the text of Fletcher's speech before he'd taken off for England with it, and she'd been flabbergasted — pleased, but flabbergasted. Over the last decade, NASA's SETI research has enjoyed broad public support and has been able to thrive on a budget that is minuscule by NASA standards. She knew that NASA's top guns were in favor of starting the SETI program as soon as possible. But in 1987 the federal bureaucracy was in the throes of a full-blown migraine thanks to the Gramm-Rudmann-Hollings budget deficit reduction law. Griffiths had already asked for the additional money needed to start her 10-year program in 1988, and she'd been shot down. She was crossing her fingers that she wouldn't get shot down twice in a row.

In February, NASA's 1989 budget request went to Capitol Hill, and all of Griffith's nearly $6 million request was included, keeping the SETI people on track to begin searching the skies in 1992. The whole shebang — about four years for preparations and six years for the search itself — will cost about $80 million, with $25 million going toward new hardware.

The SETI program is a weird one as NASA programs go: costs have gone down instead of up as the years of research have passed, mostly because of tremendous advances in key technologies such as digital data processing. The SETI research program now occupies about 3,000 square feet of NASA's space, no more than a typical suburban home. No big aerospace companies are involved (yet); NASA's SETI people are mainly scientists, computer nerds, whiz kids, and happy managers who are not prone to whining about how much more money they need. And just because we're talking about extraterrestrial beings here, don't get the wrong idea about the SETI people. There's not a flake in the bunch. The SETI



ALL PHOTOS: NASA

The Deep Space Network antenna in Goldstone, California (above) and the Arecibo radio telescope in Puerto Rico (opposite page, top) will both be used for the SETI search.

people are by and large smart, thoughtful, amazingly productive, and endlessly enthusiastic about their work.

The search NASA plans, appropriately called the MOP (Microwave Observing Project), will swab the sky for signs of intelligent life more thoroughly than all previous searches conducted to date. It is so sensible that it's hard to believe it's a product of the same agency that has been plagued by problems since the Challenger disaster two years ago. SETI is part of NASA"s exobiology program, the study of the genesis and evolution of life beyond this planet. What the SETI people are after is not a conversation with extraterrestrial beings, but simple proof that intelligent life exists somewhere, anywhere, besides Earth.

NASA's SETI strategy rests on a lot of assumptions. First, SETI scientists believe the laws of physics are the same throughout the universe, and that life cannot be peculiar to Earth. Biologists and chemists believe prebiotic conditions that led to life here could and should easily develop throughout the universe. As SETI scientist Frank Drake puts it, "We know of no freakish condition that was required for . . . us to exist."

The SETI people also assume that life eventually would lead to other technological civilizations that would choose radio signals to communicate with other worlds. The SETI scientists have chosen to search for signals within the microwave segment of the electromagnetic spectrum, at frequencies ranging from 1 to 10 gigahertz (a hertz is a frequency measure equal to one cycle per second and a gigahertz is a billion hertz. A typical FM radio station broadcasts at about a tenth of a gigahertz).

It's naturally quiet in the microwave band: at lower frequencies, natural and human-made sources of radio signals make noise, and at higher frequencies quantum effects interfere. Frank Drake and other SETI scientists who have conducted limited searches for signals of extraterrestrial intelligent origin have tuned in at "magic" frequencies, the favorite being 1.42 gigahertz, the frequency of neutral hydrogen, the most abundant element in the universe.

Lynn Griffiths:

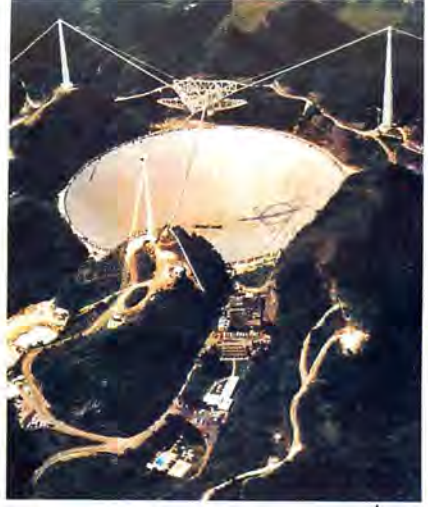
"They went through this heroic effort, and they got it done. They were all excited. It was great work, which is typical of SETI. SETI people will do anything to make their deadlines."

▼ ▼ ▼

The SETI folks will listen to, rather than send messages for a simple practical reason. Our messages would take years to reach other stars. We can receive now.

The best radio telescopes on Earth, the ones that will be used for NASA's search, might be able to pick up signals coming from halfway across our galaxy. But it won't be easy to pick out signals if they're out there: your typical Earthling radio has just 10 assigned frequencies between 90 and 92 megahertz on the dial, but the cosmic radio dial has 20 million potentially usable frequencies within the same range.

About a quarter of the stars in this galaxy, the Milky Way, are like our sun: not too big, not too hot, not too temperamental. The Milky Way is about 1,000 light years thick in the neighborhood of our solar system, a neighborhood astronomers have gotten to know fairly well, and in this neck of the galactic woods reside about a million stars that are about the same size and age as our sun. How many civilizations might be thriving among these million stars? "Ask Carl Sagan and he'll tell you a billion," says SETI scientist and Harvard



A SETI team member works on designs for an advanced signal-processing computer chip.

wag Paul Horowitz. "Are we alone as conscious beings in this entire buzzing 400-billion-star galaxy of 10^{10} other galaxies?" SETI scientist Philip Morrison has mused, "It seems pretty implausible."

NASA's Ames Research Center in Mountain View, California is directing the SETI program in collaboration with the Jet Propulsion Laboratory (JPL) in Pasadena. Ames will undertake a targeted search for signals that might be coming from a selected list of about 800 sun-like stars within 80 light years of Earth. This will multiply by four the number of targets observed thus far. The targeted search will use the 1,000-feet-diameter radio telescope at Arecibo, Puerto Rico, and the 200-foot dish antennas of NASA's Deep Space Network located in California, Australia, and Spain.

JPL will conduct the part of the search called the sky survey: 300 complete scans of the heavens, each sweep examining 3 gigahetz of the survey's full range of 1 to 25 gigahertz. The sky survey will use the Deep Space Network's smaller 112-foot antennas, and cover 10,000 times more frequency space with 300 times more sensitivity than all SETI searches to date. It also will be the first to correct for drifts in signals caused by Earth's motion relative to other planets.

Without specially developed signal processing systems, NASA's SETI program would need hundreds of Cray supercomputers, systems that are not exactly priced to buy in bulk. Instead, the targeted search will pick through two billion channels, using new multichannel spectrum analyzers (MCSAs) developed especially for SETI.

NASA will hire a contractor to build the six full-scale MCSAs for the search. Three will be installed at the Arecibo telescope because it is sensitive enough to handle 30 million channels. One will be devoted to the sky survey, and will most likely be moved from site to site. Another will be in the southern hemisphere, probably in Australia. The sixth analyzer will be at a dedicated SETI site, perhaps at Canada's Algonquin Observatory or at Ohio State University. NASA researchers are developing signal detection computer programs so that the search can run automatically, without human supervision.

Over the years, radio astronomers have recorded a few scattered anomalies, also known as "birdies" —signals picked up once and then lost— never repeated, never verified by another observer, never explained away. The automated SETI search will first check a reference catalog of known radio sources when it finds an unusual signal.

"We anticipate a lot of false alarms," says Lynn Griffiths, once the big search gets underway. NASA will keep a panel of experts on call to analyze anomalies. Griffiths said, "We're going to verify, verify, and verify before we're going to release any kind of announcement. . . . No one, *no one,* wants to cry wolf."

Astronomers interested in SETI feel a pressing need to start a large-scale search now. Radio frequency interference (RFI) has already exceeded a dull roar thanks to humankind's fascination with technology. Some SETI scientists say that if an Earth-based search doesn't get started in 1992, then we might as well forget it and move the search into space. By the mid to late 1990s, RFI will be making such a din that the only accessible place quiet enough to pick out an artificial signal coming from light years away will be the dark side of the moon. (That site is under consideration for a radio astronomy observatory, but not for the near future.)

The Jet Propulsion Laboratory's SETI program director, Michael Klein, says radio interference triples every decade, one nasty source being Earth's growing flock of communications satellites. Their signals are 10 times stronger than typical background radio noise. Even an aircraft passing overhead can interfere.

Though the odds of making contact are impossible to calculate, the SETI scientists are quick to note that it's unlikely that their search will turn up anything. The universe is seemingly endless, and the search will only check out a piece of one little galaxy in it. Nonetheless, the search will go on. Barney Oliver, chief of the SETI program office at Ames, says NASA's search probably won't be a success, mainly because it will fall a millionfold short of what would be possible if time and money were no object. Oliver believes that a dedicated SETI system operating around the clock is the way to go: he's proposed building an array of 100 radio antennas in a quiet spot such as the island of Hawaii.

Oliver has only been at NASA since 1981, but his interest in SETI dates back to World War II. He was working with automatic tracking radar, he explains, and his work led him to wonder what would happen if radar signals were beamed out one-way instead of being bounced off solid objects. "I did the calculations and I couldn't believe my eyes," he says; he saw that it was possible to communicate anywhere in the Solar System by this technique.

In 1960, Oliver read in *Time* magazine about the first-ever search for signals from extraterrestrial intelligence. The story was on Frank Drake's Project Ozma (named for

continued on page 63

CONTEST:

What happens If it works?

What do you think would be the impact on human society if a signal of extraterrestrial intelligence were received and verified? FINAL FRONTIER is interested in your ideas. Send your answer (no more than 200 words, please) to FINAL FRONTIER, P.O. Box 11519, Washington, D.C., 20008. The best entries will be published in the magazine and the top entry winner will receive a free year's subscription to FINAL FRONTIER and a NASA video on the SETI project.

R.S.V.P.

A STORY

The project began with high hopes, excitement even. Though people later came to think it just dumb, founded on a mistake so obvious that those who started it deserved its consequences, no one raised objections until well after the project was operating. True, everyone said it would be a long venture, probably not producing results for many generations. But at the beginning the newspapers carried frequent reports on its progress ("Nothing yet"). Practical jokers would call saying, "Is this the Interstellar Communications Project? Well I'm a BEM you'd be interested in talking to," or "I have a collect call for the Interstellar Communications Projects from the constellation of Sagittarius. Will you accept the charges?" It was in the public eye, looked fondly upon.

Much thought had been given to deciding what listening devices to use and what sorts of signals to study intensively. What would be the most likely wavelengths for messages to come on? Would the messages be something like TV signals rather than consecutive prose? How would one tell that a signal was sent by intelligent beings rather than produced by some natural process?

Proponents of the "argument from design," one traditional argument for the existence of God, had long wrestled with the same difficulties: couldn't any pattern, however intricate and wonderful, have been produced by some unknown mechanism? How could one be sure that an intelligence was behind it? Some foolproof test was needed, especially since, with a sufficiently complex manual of translation, any glop coming across could be decoded into an interesting message. Sending a return message and receiving a reply would take many years, perhaps generations, and it wouldn't do to have everyone on Earth jumping for joy and holding their breath if they were just talking to the interstellar equivalent of the bed-post.

The solution lay in abstract mathematical patterns, not realized (so far as anyone knew) in any actual causal mechanism and which (it was thought) couldn't be so realized. For example, there's no known causal process that generates the sequence of prime numbers in order; no process, that is, that wasn't expressly set up by an intelligent being for that purpose. There doesn't seem to be any *physical* significance to precisely that sequence, to a sequence which leaves out only the non-primes, and it's difficult to imagine some scientific law containing a variable ranging only over primes. Finding that a message began with groups of prime-numbered pulses, in order, would be a sure sign that an intelligence was its source. (Of course, something might be the product of an intelligent being even though it didn't exhibit such an abstract pattern. But a being wishing to be known to others would do well to include a pattern.)

The initial excitement aroused by the Interstellar Communications Project was connected with a vague hope that other beings would enlighten people about the meaning and purpose of life, or with the hope that at least people would learn they weren't alone. (No one explained why the 'we' group wouldn't just expand, leaving people plus the others still quite alone.) After the project was set up, the best scientists went on to other more challenging tasks, leaving the rest to wait and listen. They listened and they examined and they computed and they waited. No qualifying abstract pattern was detected, nor was any message that looked intelligent even minus such a pattern.

Since newsmen do not find a uniform diet of "no progress" reinforcing, the project was reduced, in order to fill the auditorium for their third annual press conference, to inviting reporters from college newspapers, Sisterhood bulletins, and the like. Up gets this woman to ask why they should expect to hear anything; after all, they were only just listening and not doing any sending. Why wouldn't everyone be doing the same?; maybe everyone else was just listening also, and no one was sending any messages.

It is difficult to believe that the project had reached this point without anyone's having thought about why or whether extraterrestrial beings would want to try to make their presence known to others. Even though during the Congressional debate on the subject, in all the newspaper columns and editorials, no one once suggested setting up a transmitting station, no questioner asked whether other beings would do so.

Little thought is required to realize that it would be dangerous simply to start sending out messages announcing one's existence. You don't know who or what is out there, who might come calling to enslave you, or eat you, or exhibit you, or experiment on you, or toy with you. Prudence dictates, at a minimum, listening in for a while to find out if other parties are safe and friendly, before making your presence known. Though if the other parties are at all clever, they would send reassuring messages whatever their intentions. They most certainly would not beam out TV signals showing themselves killing and eating various intelligently behaving foreigners. And if they're really clever, then (by hypothesis) they'll succeed in deceiving anyone not adhering to a policy of staying silent no matter what.

Such considerations were neither explicitly formulated nor publicly expounded, but it must have been some feeling about the foolhardiness of broadcasting first (how else can one account for it?) that led to the notable but not-then-noted absence of proposals to establish broadcasting stations in addition to the listening posts.

Once again the project was a topic of conversation. "Of course," everyone said, "it's ridiculous to expect anyone to broadcast: it's too dangerous. No interplanetary, interstellar, intergalactic civilization, however far advanced, will broadcast. For they don't know that an even more advanced and hostile civilization isn't lurking at the other end of their communications beam." Interest in flying-saucer reports diminished considerably when the conclusion was drawn that the sending out of observation ships presents hazards similar to those of broadcasting messages, since the process of a ship's returning information to its source can be tracked. (Even if a ship

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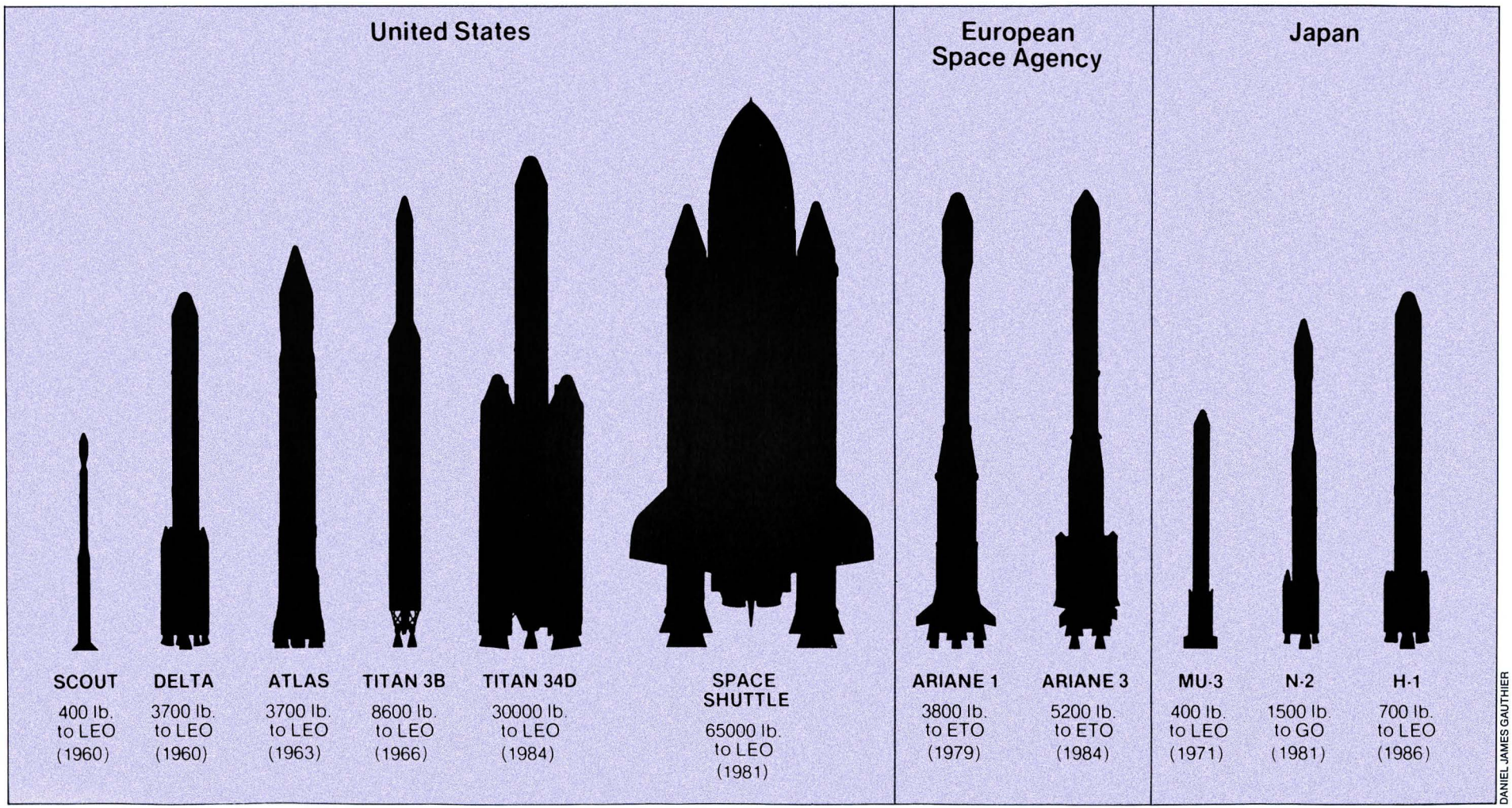
BY ROBERT NOZICK

MARGARET HUBER

DATA BASE

International Space Launchers



FINAL FRONTIER

Major launch vehicles in use as of March 1988, their lift capacity, and date of first launch. Most Low Earth Orbits (**LEO**) range from 150 to 600 miles. Communications and other satellites placed in high Geostationary Orbit (**GO**), 22,300 above the equator, appear fixed at one point in the sky. Elliptical Transfer Orbit (**ETO**) is an intermediate orbit between low and high circular orbits.

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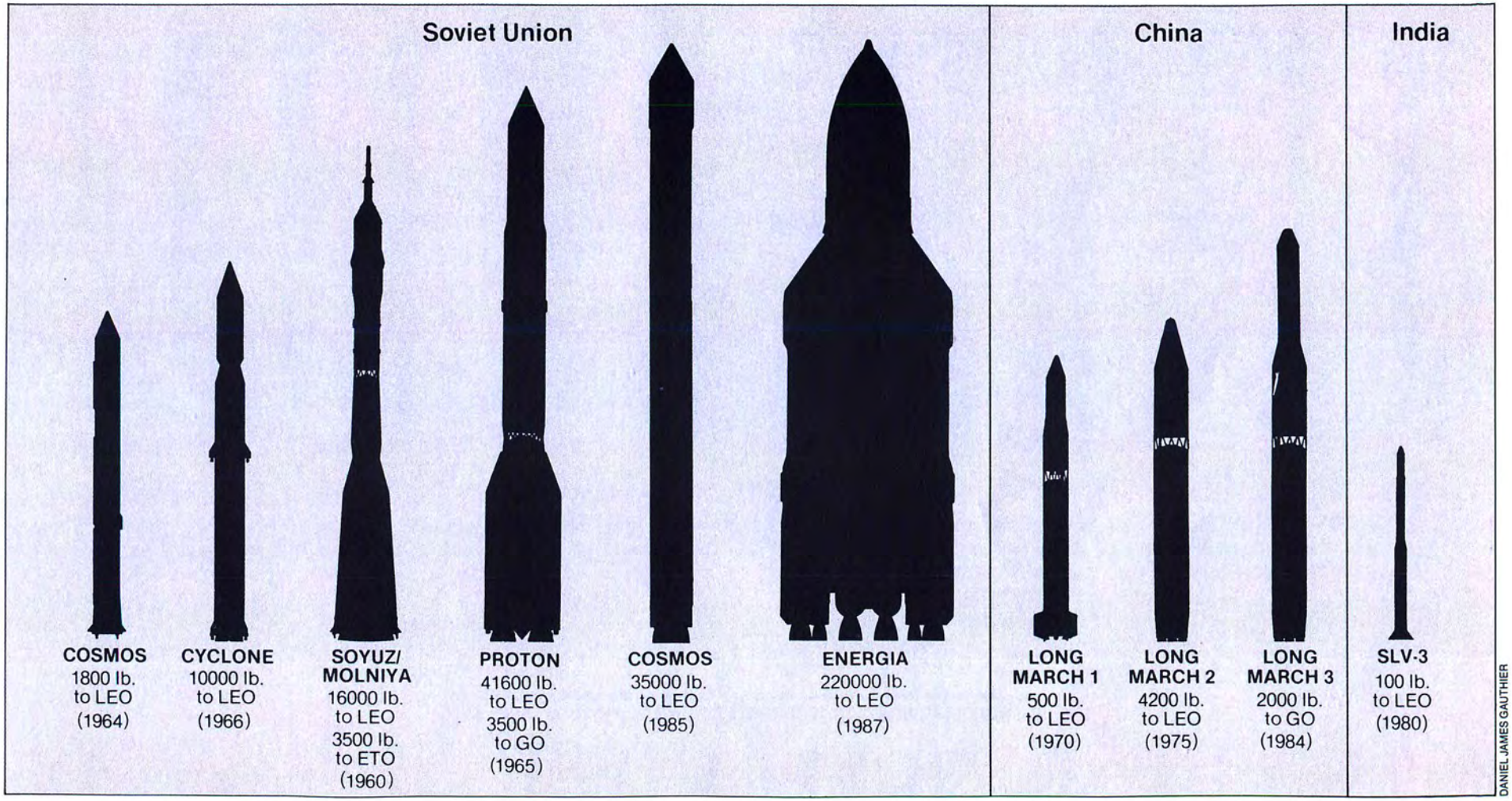
DATA BASE

International Space Launchers



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were designed to give information to its makers by *not* transmitting any physical signal, or even returning to its base, there must be some contingencies under which it *would* do so, since nothing can be learned from a detection device that gives the same response no matter what it detects.) It was said that if its planning committee had included some psychologists or game-theorists or even kids from street gangs in addition to the scientists and engineers, the project never would have gotten started in the first place.

The legislature wouldn't openly admit its blunder by ending the project completely. Instead they cut its funds. They did not authorize the broadcasting of messages. The members of the staff had various reasons for staying with the project ranging, one mordantly remarked, from masochism to catatonia. All in all, they found their jobs agreeable. Like night clerks in completely empty resort hotels, they read and thought and coped comfortably with the lack of outside stimulation. In that manner the project continued, serenely, for another eight years, with only a few comedians desperate for material giving it any mention at all; until the receipt of the first message.

Studious observation of reversals in public opinion and their accompanying commentaries has never been known to enhance anyone's respect for the public's intellectual integrity. (As for its intelligence, this would be a late date, indeed, to proclaim the news that the public adopts a view only after it is already known to be false or inadequate, or to note the general inability to distinguish between the first-person present tense of the verb 'to believe' and the verb 'to know.') People just refuse to admit that they have changed their minds, that they have made a mistake. So the very same people who said at first, "How exciting, I wonder when the messages will begin arriving," and who later said, "How silly to listen for a message; it's too dangerous for anyone to broadcast," now said, after the receipt of the first message. "Of course a civilization *will* broadcast, even though it's dangerous, if it's even more dangerous for it not to broadcast."

The first message picked up and decoded was a call for help. They were threatened by a coming supernova outburst of their star. No spaceships could escape the wide perimeter of destruction in time, and in any case they could not evacuate all of their population. Could anyone advise them about what to do, how to harness their star to prevent the outburst? Their astronomical observations had shown them that occasionally such outbursts didn't take place as predicted, and since they could discover no alternative explanation for this anomaly, they thought it possible that some civilizations had mastered a technique of inhibiting them. If no one told them how to do it, or came to their aid, they were doomed.

They wanted to know, as they died, that others knew of them, that what they had done would continue, that it would not be as if they had never existed at all.

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Over the next year and a half they beamed out their literature, their history, their accumulated wisdom, their jokes, their sage's sayings, their scientific theories, their hopes. Mankind was engulfed in this concentrated effulgence of a whole civilization, enthralled, purified, and ennobled. To many they became a model, an inspiration. Their products were treasured and they were loved. Did they view this outpouring as a gift to others, an inducement for others to help, a distillation for its own sake of the essence of themselves? No person knew or was prone to speculate as each, silently with them, awaited their tragedy. Never before had the whole of humanity been so greatly moved; never before had persons been so jointly elevated as in experiencing these beings.

At the end of a year and a half came a renewed call for aid; and in addition a call for some response, even from those lacking technical knowledge to help with the supernova. They wanted, they said, to know their messages had been received and understood, to know that what they held most important and dear would be preserved. They wanted to know, as they died, that others knew of them, that what they had done would continue, that it would not be as if they had never existed at all.

Only to the misanthropic can the ensuing debate have brought pleasure, the debate that raged among persons, and within some.

"It might be a trick, don't reply, it's too dangerous."

"Beings capable of *that* civilization couldn't be up to trickery."

"Perhaps they are quoting another civilization they've conquered, or an earlier phase of their own; Nazis could and would quote Goethe."

"Even if they're not tricking us, perhaps some other aggressive civilization will overhear our message to them."

"How can we let them perish without responding?"

"If we could help them escape their fate then certainly we should send a message telling them what to do, even though this would mean running serious risks. But we can't help them, and we shouldn't run risks merely in order to bid them a sentimental farewell."

"We can save them from believing, as they die, that they are sinking into oblivion."

"Why the irrational desire to leave a trace behind? What can that add to what they've already accomplished? If eventually the last living being in the universe dies, will that mean that the lives of all the rest have been meaningless? (Or is it vanishing without a trace while others still remain that is objectionable?)"

"How shall we face our children if we don't respond?"

"Will we have grandchildren to face if we do respond?"

No government sent a message. The United Nations issued a proclamation beginning with a lot of "whereas's" but containing near the close a gathering of "inasmuch's" so it didn't proclaim its proclamation of regret very loudly. But it did issue an order, in its stated role as guardian of the interests of the Earth as a whole, that no one endanger the others by replying. Some disobeyed, using makeshift transmitters, but these were seized quickly, and their signals were too weak to reach their destination intact through the interstellar noise.

Thus began the grim watch and countdown. Watching for their rescue, listening for some word to them from elsewhere. Waiting for their doom. The time, for which their astronomers and Earth's also had predicted the supernova outburst, arrived. Some persons paused, some prayed, some wept. All waited, still.

The existence of a finite limit to the velocity of causal signals had been of some interest to physicists. Epistemologists had worried their little heads over the question of whether what is seen must be simultaneous with the seeing of it, or whether people can see far into the past. Now came the turn of the rest. The fate of that distant planet was already settled, one way or the other, but knowledge of it was not. So the wait continued.

For another year and a quarter, remembering their debates, mulling over their actions and inactions, contemplating the universe, and themselves, and the others, people waited. Poetically just things could have happened. A message could have arrived saying it was humanity that had been tested, it was the Sun that was due to outburst, and since the Earth's people hadn't ventured to render others aid or comfort, others would not help them. Or, they could have been rescued. (How greatly relieved people then would have

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This summer, two Soviet probes head for the moons of Mars, packing hoppers, lasers and a whole lot of flags.

BY CHARLES R. PELLEGRINO

MISSION TO PHOBOS

Airless worlds are always hauntingly beautiful. Phobos is especially so. Even after dark, the landscape of this tiny Martian moon is spectacular. The disk of Mars, scarcely 3700 miles away, covers half the sky, reflecting a hundred times more sunlight than the full moon on a clear night on Earth. The rocks on Phobos' surface are dark gray, almost black; but if you stood there you could easily notice details in a crater wall, blood bright and starlight cold in the glow of Mars.

Phobos is an offshore island of the red wilderness, measuring only 16 miles long and 11 miles wide. Sweeping overhead in an orbit almost 9000 miles higher, the jagged, silver crescent of tiny Deimos is the next nearest and next brightest object in the night sky, followed by the blue-green half phase of distant Earth.

If there had been sentient beings on Phobos, they would have noticed unusual stirrings on the blue planet within the past few revolutions around the Sun. A dozen revolutions ago, aluminum and silicon shapes called Mariner

NASA

were hurled away from the Earth. They arrived and darted beneath Phobos, occasionally casting an idle lens at her, then turning their attention to the red giant below. More shapes called Viking followed, rising from the Earth like summoned spirits. Almost without exception, they showed a contemptuous lack of interest in Phobos, as they hurried on to more important concerns.

According to the standards of time measured by a pebble in space, a storm of earthly invasion has burst upon Mars, and a new invader is about to arrive. This July, two Proton rockets will lift off from the Baikonur Cosmodrome in Soviet Central Asia, each pushing a robot spacecraft toward Phobos.

Close examination of these machines would hint at subtle changes in the behavior of their makers. So far, all the vehicles bound for Mars have borne either Soviet or American markings. These latest arrivals will carry the flag decals of many nations; Austria, Bulgaria, Czechoslovakia, East and West Germany, France, Hungary, Poland, Sweden, the European Space Agency and the United States are all contributing instruments and scientists to the Soviet project. Not only does the Fobos project represent a high water mark for Soviet planetary exploration, it is also one of the most international space missions ever launched.

"It is very interesting to work with Soviet colleagues who are space scientists," says Brown University geologist Jim Head, who, as one of the American scientists assigned to the mission has visited the Soviet Union five times during the past eight months. "It's another whole community that shares a common interest in something that is truly mysterious and beautiful."

Head says that part of the project's excitement is the great number of experiments having to do with the structure and composition of Phobos, which is believed to be a captured asteroid. "We're kind of getting a two-for-one deal: exploring a major moon of Mars and at the same time understanding the asteroids in detail," he says.

Phobos was almost certainly once part of a larger object or "parent body." It resembles a giant core stone whose outer layers have been exploded away by a collision with an asteroid. If that doesn't seem particularly dramatic, the moon's orbit also is decaying rapidly. In only a few million years—next week by the time standards of the Solar System — it will crash down upon Mars.

Drawn together by the enigma of Phobos, scientists from normally antagonistic nations are, to one degree or another, discovering their common humanity. "I guess that's so," says Head. "I take it a day at a time. If one took a long-term view, I think increased communication can lead to better understanding, so that's a real important thing all by itself. Presumably we are lessening international tensions as we explore new worlds together."

Looking somewhat like chandeliers with solar power panels, the two Fobos spacecraft will arrive at Mars in January 1989. Whirling 300 miles above the Martian equator, the two craft will first turn telescopic eyes toward dust devils and cyclones on the planet, and toward the Solis Lacus region in Mars' southern hemisphere. There, an oasis of volcanically heated and "outgassed" water hints at a reservoir of salt water located a mere yard below the surface. Spectrometers onboard Fobos will measure the abundance of water both at the surface of the volcanic plain and several inches below it.

In late February, one of the machines will climb out of its parking orbit to an "observation orbit" 200 miles higher than Phobos. Closer to Mars and confined to a tighter orbit, the moon will have a higher angular momentum than the probe, and will appear to cover more ground. Despite the fact that it is actually flying faster than Phobos, the spacecraft will trail slightly behind.

ANDREI SOKOLOV COURTESY SPACE ART INTERNATIONAL

An onboard laser will churn up dust from Phobos for sampling.

During the month that follows, the craft will measure precisely its movements relative to Phobos. Then a command from Earth, fully six light-minutes away, will fire the probe's thruster directly against the path of flight, demonstrating one of the

Will the Soviet Union Land the First People on Mars?

The Soviet Union's Phobos mission, planned for launch this summer, is that country's first expedition to Mars since the early 1970s. As James Oberg points out in his recent book, *Uncovering Soviet Disasters,* "The Red Planet has proved to be one prize in the sky that has remained stubbornly beyond the grasp of Soviet exploration."

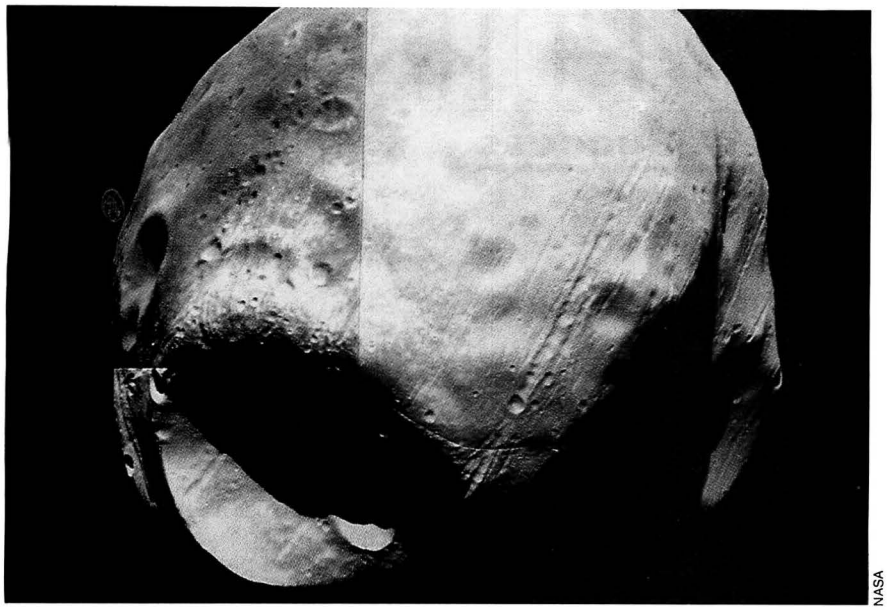
An engineer with the space shuttle program at NASA's Johnson Space Center in Houston, Oberg is also a leading western expert on the Soviet space program and the author of *Red Star in Orbit.*

FINAL FRONTIER talked with him in March about the renewed Soviet interest in Mars and what it implies for more ambitious missions of the future.

Final Frontier: *In Uncovering Soviet Disasters,* you say that it's taken the Soviet space program 15 years to get up the nerve to go back to Mars.

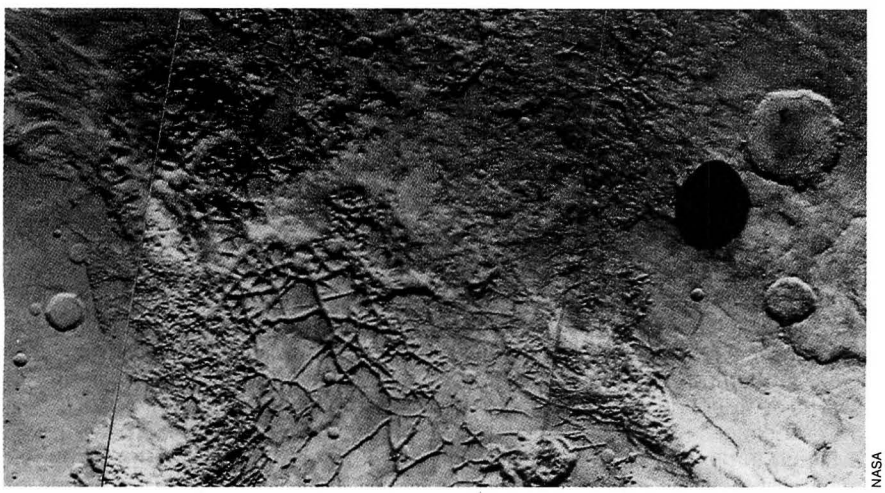
Oberg: They've had two separate Mars programs — the first in the early 60s, the second in the early 70s — and they were terrible failures. They had difficulty getting the payloads en route, and once they were en route they had major lifetime problems [breakdowns], because Mars is much farther away than Venus. More than half of the Soviet Mars-bound payloads have just broken down en route.

But what we've seen in the past ten years is a very impressive extension of Soviet spacecraft lifetimes, especially the planetary spacecraft. The Vega probes lasted 15 months between launch and Halley's Comet encounter, and another year afterwards. They've had the Venera 15 and 16 radar mappers in orbit around Venus for three or four years, operating



NASA

Phobos' dramatic Stickney Crater resulted from an asteroid collision in the moon's early history. The Viking I orbiter took this photograph of the dark satellite silhouetted against the Martian surface (below, right) in 1977.



NASA

paradoxes of orbital mechanics: if you want to speed up and catch Phobos, you have to slow down.

The craft will slow, and Mars will tighten its gravitational fist, yanking the probe down 200 miles and tossing it ahead toward the orbiting moon. Flying in parallel with Phobos in a matching orbit, the ship will in effect be hovering some twenty miles above the surface. It will remain there for close to two months, taking photographs and fine-tuning its relative motion.

Then the thrusters will fire again, and Phobos' feeble gravitational field will pull the ship into what Roald Kremnev, director of Moscow's Babakin Center of the new civilian space agency, calls a "controlled fall." Veteran American planetary scientist Harold Masursky of the U.S. Geological Survey calls it "a maneuver so damned complicated, it's absolutely hair raising."

The 20-mile fall will take about an hour, and will place the craft into a very slow, grazing orbit a mere 150 feet above Phobos. This close encounter lasts just fifteen minutes. Any longer and the orbiter would not be able to keep from falling into the moon, where it would bump along the surface at about ten miles per hour. Even though Phobos' gravitational field is so weak that a person standing on its surface would be able to hurl stones at Mars, the spacecraft could avoid crashing into the moon only by firing its thrusters. This would contaminate the surface with fuel exhaust, throwing all chemical analyses of the rocks and soil into question.

Drifting leisurely over crater rims, the Fobos craft will be an earthly parody of the glittering monstrosities imagined by H.G. Wells in his *War of the Worlds.* As a crowning irony, it even comes equipped with a heat ray. A high-power onboard laser will

continued on page 60

successfully. The Astron observatory has been orbiting five years in a high-Earth orbit, and that is very impressive. That gives good promise that their new Phobos spacecraft is going to overcome these problems.

Final Frontier: So do you think they're going back to Mars now because they *can?*

Oberg: They're going back to Mars now because they've done all they can on Venus. . . . and now they're turning their attention to Mars with a lot more muscle than they had back in the 70s. They're still stuck with the Proton launcher, and the Proton launcher is a limitation to them. It isn't powerful enough to bring the spacecraft to trans-Mars insertion [orbit], so they'll be doing some complex maneuvering, including burning the Phobos spacecraft's service propulsion system, for the final insertion. That's fairly complex, and it involves several Earth orbits to do that. So I have some anxiety about that, because it's something new, and upper stage propulsion has never been their strong suit.

They've shown they can do the navigation, and they've shown they can do the lifetime and the communications. So they have a lot better chance now than they did 15 years ago. And if something is just not going to work, they're now in a position of delaying it or re-flying the mission two years from now with backup hardware, without a whole lot of pressure from American competition. They don't have the [1976] Viking [Mars] project breathing down their necks, giving them no room for error.

Final Frontier: Do you see the Phobos mission as a precursor to manned Mars exploration? Do you think the Soviets are working on sending humans to Mars?

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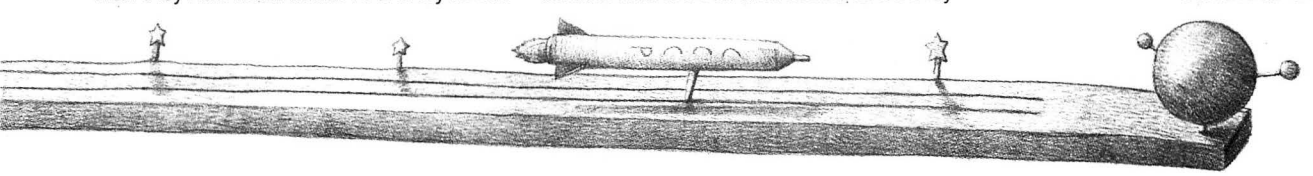


RICK PETERSON

EARTHLY PURSUITS

Sweet Success

This spinoff keeps electric bills from reaching orbit.

▼ ▼ ▼

By Beth Dickey

They've kept orbiting satellites cool for decades. Now, NASA heat pipes are putting the chill on earthly power bills.

A major confectioner saved a sweet 88 percent recently by adding a bit of space technology to his manufacturing plant in Albany, Georgia. Bob's Candies let the Florida Solar Energy Center install a four-by eight-foot heat pipe in its 45,000 square-foot warehouse last summer. The Center's energy experts wanted to know if this space-age cooling equipment would be economical to use in private industry. The world's largest candy cane maker was surprised to find out just how economical it can be.

Heat pipes have been used in one form or another since the 1940s. NASA developed them to cool the electronic components on the "sun side" of spacecraft, where temperatures can easily reach 250 degrees Fahrenheit. The pipes have been used on about 70 percent of American satellites and on the Skylab orbiting station in the 1970s, and will be used on the Hubble Space Telescope set to be launched by the space shuttle into Earth orbit in 1989.

Law requires NASA to share its inventions with the public, and the non-profit Florida Solar Energy Center at Cape Canaveral, Florida, is spinning this one off for the space agency. Bob's Candies and Georgia Power agreed to test the theory that heat pipes can reduce air conditioning costs by removing humidity from the air inside a room as it's being cooled.

Company president Bob McCormack Jr. thought he was seeing things when he opened his mail from Georgia Power. The electric bill was $7,000 less than it had been for July of the previous year. July is typically the hottest, sweatiest month of the summer in Albany, and this one was no exception. But it also was the first month the heat pipe had been used.

"In the first two months we saw any figures, it far exceeded anything we expected," said McCormack. "We would have been satisfied with 25 to 33⅓ percent savings. I understand we're saving 75 to 80 percent or more." In fact, the average savings are more than double what were expected when the $100,000 shared cost experiment began. The company usually spends $57,000 a year to cool and dehumidify its warehouse.

A heat pipe works by convection, without using energy. It cools the warm air that enters an air conditioner and heats the chilled air blown back into the room. Each heat pipe is a sealed tube containing water or some other liquid refrigerant. The pipe has two sections: an evaporator, which picks up heat; and a condenser, which releases heat.

When the heat pipe is placed between the warm air in the room and the cool air supplied by the air conditioner, the liquid refrigerant absorbs heat from the warm air, evaporates, and passes into the condenser section as vapor. The vapor then condenses on the inner wall of the heat pipe, transferring heat to the cold supply air. The newly condensed liquid returns to the evaporator section by force of gravity.

Simply turning up your thermostat, as many utility companies recommend, creates indoor humidity problems because the conditioned air comes out warmer or moister. Turning the thermostat down to remove the moisture not only defeats the attempt to conserve power by keeping a steady room temperature, but also makes the indoor air uncomfortably cold.

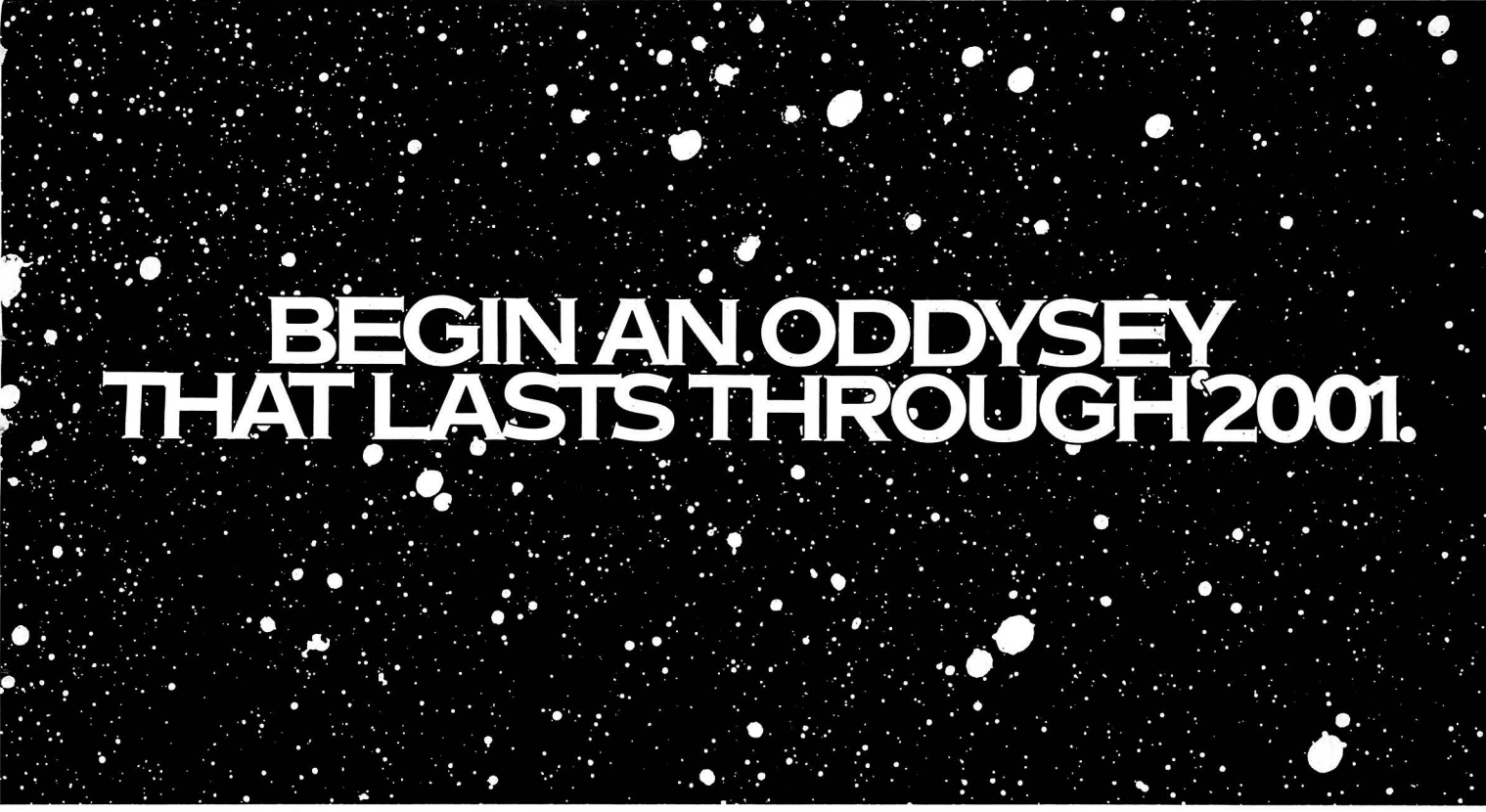
Because heat pipes can block air flow, units that use them often need more powerful fans. But the Bob's Candies test apparently has proven that the reduced cost of air conditioning more than makes up for the added equipment cost.

Now, heat pipes are keeping Bobs' candy canes melting in your mouth, not in the warehouse. At peak production, Bob's makes 6,000 pounds of sweets each hour—as much as 25 million pounds every year. Seventy-five percent of the candy is sold during the winter holidays, and is stored beforehand for as long as nine months. Unless the temperature is maintained at 78 degrees and the relative humidity is kept constant at 40 percent, the candy "grains" and "bleeds." Humidity makes the stripes run. McCormack says he likes soggy candy best, but since "most people buy candy canes as a decoration rather than to eat," heat pipes are now being used to dehumidify the building where Bob stores his Christmas stock.

"We can look at their bill and just see the impact in dollars and in kilowatt hours," said Sam Wills, an industrial marketing representative for Georgia Power. The utility company is watching for possible heat-pipe applications in its own power plants. "We did not anticipate the results we received and we are very happy with the way this has turned out."

The executives at Bob's Candies, although they still can't believe the figures, aren't complaining. "If Georgia Power will accept that they're sending that small a number of electrons in here, and that's all they're going to charge us for," said one company engineer, "I don't think anyone here is going to question it." □

STAN OLSON



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Supercomputing the Cosmos

When the Hubble Space Telescope roars into orbit sometime next year, astronomers will get a chance to look at objects whose light traveled 5 billion years before reaching our planet. But even that instrument, as advanced as it is, will not see to the edge of the universe. That region of space and time is the province of the imagination, and, increasingly, of predictions calculated by the supercomputer.

"In simulations run on our Cray computers and in plasma experiments in the laboratory, we show how immense electromagnetic forces can shape 'clouds' of plasma into every known type of galaxy in the universe," says Anthony Peratt of the Applied Theoretical Physics division at Los Alamos National Laboratory in New Mexico.

Peratt and his colleagues believe that 99.999% of the universe is composed of plasma — energetic, electrically charged particles scattered in space, which is very cold and nearly a vacuum, and yet "filled with titanic electrical currents and vast magnetic whirlwinds."

This is a relatively new idea, brought to the forefront by Cray supercomputers. What would take billions of years to happen in space is conjured up in the circuitry of these computers in just hours. And the results suggest that the universe may be a whole lot different than most astronomers and astrophysicists believe today.

For the most part, gravity has been thought to be the major force guiding the evolution of galaxies, stars and planets. But work on Cray computers at the Los Alamos National Laboratory indicates that the universe is shaped more by the electromagnetic force unleashed by supercharged plasma than by gravity.

Exit the Big Bang Theory.
Enter the Plasma Universe.

▼ ▼ ▼

By Greg Freiherr

What does plasma power do to our visions of the universe? According to Peratt, a universe based on electromagnetism and gravity rather than gravity alone does not need a 'big bang' as its starting point. "The 'big bang' theory requires that the universe be very smooth; that the energy background be very homogenous," he says. "And we have found out through measurements of space that the universe is not smooth at all. So, without a big bang, its age could well exceed the 10 to 20 billion years now estimated and it could be very much larger than we have imagined."

Plasma power might also explain certain mysteries, particularly energy bursts characterized by cosmic radiation and 'galactic jets,' beams of charged particles emitted by radio galaxies. These, according to Peratt, might be the thunder that comes from the tangling and breaking of energy threads 50,000 light years in diameter and hundreds of thousands of light years long. Inside these threads or filaments, Peratt says, are whole galaxies.

Peratt and his colleagues at Los Alamos have seen these threads, if only on the screens of their supercomputers. They emerge from the primordial plasma, electrical currents rippling through them, forming powerful magnetic whirlwinds called vortices that spin while hurtling through the universe at 1,000 kilometers per second, sucking in particles, dust, everything in their path.

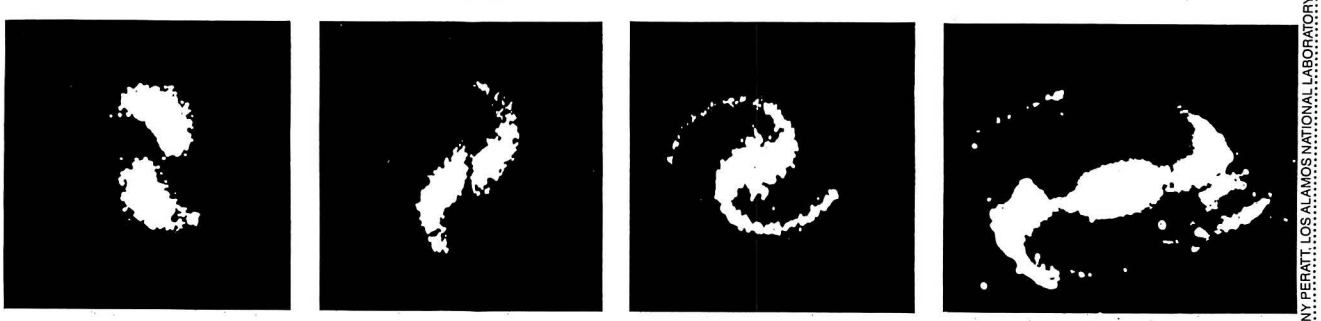
"Over time our simulations show the filaments tangling, twisting, and breaking into galaxies and clusters of galaxies," Peratt says.

Are these supercomputed concoctions — these convulsing threads of energy — so strange, so mysterious, so profound? "They're commonly found on earth," he says. "Small-version vortices are known to power microwave ovens, radar systems and laboratory energy experiments. One would expect that electromagnetic filaments can create the same spiral structures in the universe — only on very large scales. And that's what our research is demonstrating."

The research began about eight years ago, "purely by accident," Peratt says. "We didn't expect to see any of this. We were investigating plasmas in laboratory and space environments — but only in space simulations of the solar system. Then we started to see parallels with astrophysical phenomena." Since then he and his colleagues have been "benchmarking" their simulations — using the supercomputed predictions to find new data or uncover data that had been overlooked, then plugging those facts into the simulations to see if the results were unchanged or further clarified.

These last eight years have been a long haul for the scientists. "When we started out, our ideas weren't received very well by astrophysicists and astronomers," Peratt says. "Now they've gotten quite interested, and for the first time some of them have conceded that we're either a few years ahead—or we're totally wrong." □

Los Alamos supercomputers can simulate in hours what took nature billions of years: the formation of a galaxy from two clouds of electrically charged gas.



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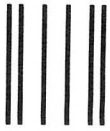

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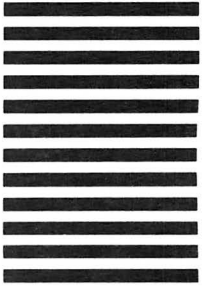

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REVIEWS

Voyage to the Outer Planets and Beyond
A VCR Space Adventure
Today Home Entertainment
VHS and Beta: $39.95

By Tony Reichhardt

A few years ago, shortly after Voyager returned the first close-up photos of Jupiter and Saturn, album covers for Gustav Holst's orchestral suite *The Planets* began popping up in record store windows, sporting brand new NASA pictures under Deutsche Grammophon and Angel labels. Classical music had met the space age.

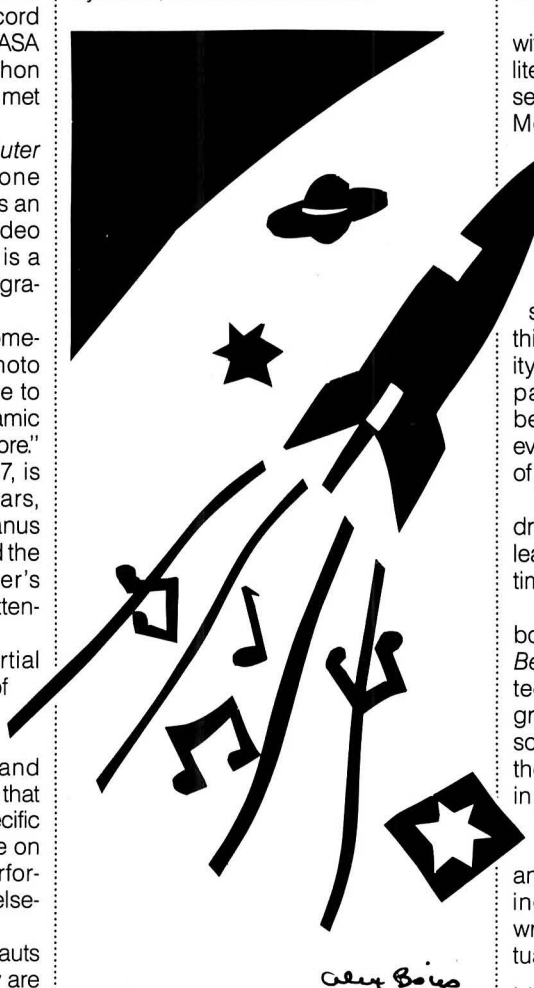
The producers of *Voyage to the Outer Planets and Beyond* have gone one medium further, using Holst's work as an aural backdrop for their "musical video voyage in outer space." The result is a highly listenable hour of space photography, and sometimes more.

The film's researchers did their homework, sorting through old NASA photo albums, animations and film footage to come up with the best and most dynamic planetary images to match Holst's "score." His suite, composed from 1914-1917, is divided into seven movements: Mars, Venus, Mercury, Jupiter, Saturn, Uranus and Neptune, and the filmmakers had the good sense to follow the composer's sequence, even if he didn't pay any attention to nature's.

So we begin with Mars. The martial tones that Holst wrote in the midst of war-torn Europe are played against the firestorm of a rocket launch. For the most part, the linking of sight and sound is equally good. (We're advised that the producers have "subtly altered specific musical phrases to match the picture on the screen," creating a "unique performance of *The Planets* not available elsewhere." Purists, take note.)

When it comes time to show astronauts romping on the lunar landscape, they are accompanied by the *adagio* strains of the Venus movement, since Holst neglected to write the Moon into his suite. The effect is tranquil, almost mystical, very different from the bombast of flag-waving NASA films made at the time of the Apollo landings. You're sorry to see this movement end.

Even the most jaded space video junkies will find a few delights — old images of a Mariner spacecraft's approach to Mars and a time-lapse series of Viking photographs showing a Martian sunset, for example. Although the producers claim to have included the latest images of Uranus, none of the actual Voyager photos, which are spectacular, appear. Instead we get animated previews of the 1986 flyby, which are probably more dynamic, but not as authentic.



The producers apparently got worried at some point that the music and pretty pictures would not be enough to carry the marketing ball by themselves. So we're given a good dose of education with our tour. Not only does the cassette come with a color NASA brochure on the planets and a data sheet on eclipses, comet visitations and the like, we are also treated to digital displays that pop up now and then at the bottom of the screen.

These, we're told, are courtesy of the "Henry 505 Navicomputer," who is presumably too cute to resist, although we never see him. Henry's data readouts about masses and distances and such are superfluous at best (they go by too fast to absorb) and annoying at worst.

Then there's our host, Isaac Asimov, with his serious sideburns and prodigious literary output. (Among the most recent selections from this one-man Book of the Month Club are, *The Annotated Gilbert and Sullivan* and *The Relativity of Wrong,* a collection of essays reprinted from *The Magazine of Fantasy and Science Fiction.)*

Despite his easy authority and his top billing on the cover of the videocassette's box, Asimov, like Henry, is something of a weak link. As a video personality, he, uh, makes a good writer. But his part is brief — a couple of walk-ons between movements — and his words, even if they aren't delivered with the grace of Olivier, show flashes of wit.

The film is best when it settles down and drops the computer readouts and Asimov, leaving just Holst and the planets. At these times it is both absorbing and profound.

Science writer Timothy Ferris, in his book *Space Shots: The Beauty of Nature Beyond Earth,* writes: "The aesthetic and technical merit of astronomical photographs improved together, and it became something of a maxim in astronomy that the more clearly one could see an object in space, the more beautiful it looked."

Ferris is one of the more "literary" science writers on the scene today. He and a handful of others like him are helping to bridge a culture gap C.P. Snow wrote about in the 1950s: "Literary intellectuals at one pole — at the other scientists . . . between the two a gulf of mutual incomprehension."

This video, in a small way, aids that same cause by setting high-tech images to high-brow music. It reminds us again that the pictures, stripped of all their science and numbers and intellectual clutter, are, simply, beautiful. □

Beyond Spaceship Earth: Environmental Ethics and the Solar System
Edited by Eugene C. Hargrove
Sierra Club Books
332 pages, plus index, $25.00

By Ed Regis

Is the Solar System just so much raw material, gobs of matter to be used and disposed of as we wish? Or are the whirling orbs in fact separate worlds with their own integrity, entities that must be protected from the ravages of humankind?

This non-technical collection of essays attempts to apply environmental ethics to the Solar System at large, and to raise what may, for many readers, be new moral questions about the colonization of the last frontier. The authors, who include philosophers, politicians, scientists, businessmen and a theologian, are concerned with the proper use of the Solar System's planets, satellites and asteroids.

Most of the volume's contributors are a lot better at asking these questions than answering them, but a few practical suggestions do emerge from the discussion. One is the concept of a "space wilderness area," modeled after wilderness areas here on Earth. The idea is that certain places in the Solar System would be declared off limits from commercial exploitation, while others could be explored, mined and used at will. The Moon's Tranquility Base, for example, would be preserved because of its historical value, while the lesser asteroids could be gobbled up for their resources.

The book's best essay is "Space Exploration and Environmental Issues," by artist, writer and astronomer William K. Hartmann. Hartmann points out the strange situation that many environmentalists find themselves in when they first consider the prospect of moving industry out into space. On the one hand the prospect is appealing, for with factories displaced to the Moon or elsewhere, industrial pollution could be forever banished from the face of the Earth. But the vision of a vast human migration into the interstellar deep is also profoundly disturbing: it encourages what Hartmann calls "a 'disposable planet mentality' — a tendency to squeeze our planet dry and then move on to the next."

Although he is sensitive to environmentalist concerns, in the end Hartmann presents a well-argued case for space resource utilization. His answer to the "disposable planet" dilemma is that going into space is not a panacea, but rather an insurance policy for Earth: "To argue against space survival insurance on the grounds that it fosters a disposable planet mentality is like a crazy man's response to the fire chief's warnings about fire hazards on [a] luxury liner. Instead of helping the passengers with lifeboat practice, he burns the lifeboats on the grounds that this will encourage the passengers to be more careful with matches." □

Ed Regis is Associate Professor of Philosophy at Howard University and the author of Who Got Einstein's Office? Eccentricity and Genius at the Institute for Advanced Study.

Welcome to Moonbase
By Ben Bova
Ballantine Books
254 pages, $9.95

Mars 1999
By Brian O'Leary
Stackpole Books
160 pages, $14.95

By Kerry Mark Joels

I read these two excellent books with some sadness. They are the latest manifestations of a literary form which might be called "science faction," where the reader is involved as a vicarious witness/participant in future space exploration, with the imaginative scenarios based rather solidly on reality.

Ben Bova's *Welcome to Moonbase* places you on the Moon's surface at the end of the second decade of the 21st century. Complete with contracts, procedures and even tax policies, he paints a detailed picture of what life in the lunar environment will be like. Bova's "manual" details the Moon residents' work in space transportation, manufacturing and research, as well as their recreational activities. The book concludes with an historical retrospective that includes "firsts" from Apollo 11 as well as fictional achievements of the later settlers. While it lends an air of believability, this section also reminds you that you are reading fact mixed with fiction — a sense you lose in earlier chapters.

In *Mars 1999,* Brian O'Leary gives a "personal" account of his trip to the Red Planet at the close of this century. Alternating between first-hand narrative and straightforward science fact, he weaves a cogent and compelling story. Sometimes, though, I wanted to be left in the narrative. For an engineer, O'Leary has a good feel for interpreting human emotion, and the book is strongest when he lets his technically proficient humanism show through.

Mars 1999 is a sort of blend between James Oberg's *Mission to Mars* and my own *Mars One Crew Manual.* Were it not for the uniqueness of the fictional narrative, the book might be just another summary of the "Case For Mars" conferences held over the past few years to develop strategies for Mars exploration. As it is, O'Leary presents a compact and interesting read on human exploration of the Red Planet.

Why the sadness then? Because it would seem that the subject of space exploration needs this kind of treatment to be successful. Would Willy Ley or von Braun have approved? Of course, but they would have held us spellbound with the exciting real prospects of lunar bases and Mars missions.

No, we're a more sophisticated lot now, and it's a little sad. Space nuts were few then, and they still are. What do we have to do to tap that latent excitement that will make space exploration a national priority?

Bova is fond of saying that futurists are science fiction writers with the creativity beaten out of them. He needs to be careful. Science faction blurs the distinction. The recent glut of "manuals" written for the space shuttle, Mars, space colonies, and now the Moon leaves little doubt that participatory space books have arrived. We can only hope they broaden the public's interest in real space programs. □

Kerry Mark Joels is co-author of The Space Shuttle Operator's Manual *and author of* The Mars One Crew Manual. *He is currently on the staff of the Challenger Center for Space Science Education.*

Solo

(continued from page 26)

because you're using the orbiter as your reference frame. Imagine if your only orientation is looking at something—that's the only way you can tell up, down, left, and right. And imagine that begins turning, but you don't know if you're turning or it's turning."

All agreed that judging distances and speed during their sorties was very difficult. "There are lots of subconscious tricks you use for judging distances on Earth," said Allen. "Shadowing and clearness of the object give you hints, because in the atmosphere, air's a little dirty and objects far away look less clear to you. But those cues are missing in space. Also, if you are looking at an object, you don't know what it is. You can't tell the size of it—whether it's a piece of tin foil very close or a big chunk of sheet metal far away. You have nothing to relate it to."

"You lost depth perception out past 70 or 80 feet," said Stewart. "Because you're moving so slowly with the MMU—only 1 or 2 feet per second (i.e., slower than walking)—it's very difficult to tell if you're closing with the orbiter or receding from it." (At full throttle, the backpack could reach speeds up to 30 miles per hour in space, but this would be impractical and even dangerous—the astronaut could use up all his onboard fuel and be left stranded in orbit.)

"We had a stick we could hold up, with notches cut in it, to measure the orbiter and tell how far from the orbiter we were," said Stewart. "But you have to wait ten or fifteen seconds to see any difference in the orbiter size. Same with motion. When I got out to 300 feet and Vance said I was getting out too far, I thrust what I thought would stop me, the opposite of what I did to get started. I'd say 'How does that look?" and he'd say, 'You're still moving.' On the way back, I had to be very close—within range of pickup by the arm—before I could judge my rate of closure with just vision."

Although the MMU hypothetically could carry an astronaut up to a mile from the orbiter, it makes everybody nervous to think about going that far. The fuel supply is very limited and fuel is used for everything—stopping, going, changing and holding position. According to Stewart: "If you stay close to the orbiter, you can approximate a straight line. But out beyond 1000 feet, it takes more fuel to counteract orbital mechanics effects, and you might need some little onboard computer to help—to give you sightings and lay a path back."

Also, MMU sorties have all been very short, some only a few minutes in duration. And they have always been scheduled during the 50-minute daylight portion of an orbit, never in darkness. Most feel night flying would be no problem. "The MMU has strobe lights, the helmet has a light, there are lights in the payload bay," said Nelson. "Although Earth is dark, you can see the horizon. The Earth always looks different than the sky, even though both are black. The Earth has city lights, clouds, lightning, and it doesn't have stars."

All the MMU veterans agreed that the experience of being a human satellite is difficult to describe because it's not like anything on Earth. But they also agreed that it was not what it appeared to be: perfect human separateness.

"In low Earth orbit, the Earth was right there and all the time the radios were crackling," recalled Stewart. "Even though I couldn't talk, I could listen. I had contact all the time. During the Apollo missions, one guy was orbiting the Moon and was on the far side of the Moon part of the orbit. He was out of touch literally with all humanity, the rest of the universe. Now *that's* real solitude." □

Alcestis Oberg was a semifinalist in NASA's Journalist-in-Space competition. Her most recent book (written with her husband, James Oberg) is Pioneering Space: Living on the Next Frontier. *She lives in Galveston County, Texas.*

Mission to Phobos

(continued from page 53)

zap the moon's surface repeatedly. In quick succession, small and widely separated points of rock and dust will flash into puffs of white plasma, so that samples can drift up to sensors on the hovering probe.

"As it explosively evaporates," explains Yuriy Zaytsev of the Soviet Academy of Science, "approximately a million particles will be trapped by the vehicle during each cycle of the laser. Instruments will then determine the composition of the particles and send the data to Earth, where analysis makes it possible to study the elemental composition of the Phobian surface."

Finally, before it leaves, the vehicle will drop two landers, making direct contact with Phobos for the first time in history. One lander will anchor itself to the surface, drill a hole, and analyze its contents. The second, called a "hopper," will study the chemical makeup of the soil, then hop on springloaded legs to another location.

Able to leap fifty yards in a single bound, the hopper will set out on its gadabout exploration of the tiny moon, carrying with it a West German-built spectrometer that will compare the soil composition at different locations with results from the mother ship's laser experiment. In between hops, French-designed cameras will take 360-degree panoramic views.

Meanwhile, the mother craft will settle into an orbit only a mile and a half above Phobos, and sprout 20 yard-long whisker radar antennas with which to probe beneath the Phobian surface to a depth of 150 yards. From low orbit, telescopic cameras will map the entire surface, revealing details only three inches across.

If this ambitious list of experiments goes well, the plan is to use the second spacecraft to explore Mars' other moon, Deimos. By mission's end, the Soviets will have conducted the most thorough reconnaissance of any satellite in the Solar System other than our own Moon.

What do they hope to learn? Already we know that Phobos appears to be a large carbonaceous chondrite. These stony, carbon-rich meteorites are among the most fascinating objects known, filled with a mixture of tiny diamonds, complex organic molecules and ice.

The Earth and the asteroids (from which both Phobos and the meteorites appear to have been born) were formed 4.6 billion years ago. But the once warm and wet asteroids froze through to their cores during the first half billion years of the Solar System's history. In Australia and Africa, living cells entered the fossil record 3.5 billion years ago. Life formed with surprising rapidity. Was the same life-building process independently duplicated in underground streams on Phobos' parent asteroid? If we want to know what the first steps in the direction of life must have been like,

we may have to extend our search for fossils to Phobos.

But the Fobos orbiters and hoppers were not designed for paleontology. Their builders have more practical concerns. Carbonaceous chondrites are rich in oxygen, carbon and hydrogen— all of which can be used, in various combinations, as propellant for chemical and nuclear rockets.

The first human visitors to Mars will probably stop first at its offshore island, Phobos, bringing with them equipment for extracting oxygen, hydrogen and/or carbon. If a Phobos refinery proves successful, both manned and unmanned Mars landers could eventually be carried to Phobos with their tanks empty. Not only would this reduce the size and expense of the Earth-Mars transport vehicle, but it would totally transform the design and economics of landers. A refuelable Mars lander could be designed with total reusability in mind.

Next July, two new pieces of the Earth—the first in more than a decade—will detach and fling themselves toward Mars. But the inhabitants of Earth have raised their sights from scouting to prospecting. To a Mars-based observer, the implications of the laser-assisted prospecting mission would be clear. Sooner or later, the humans themselves are bound to follow. □

Charles Pellegrino is the author of four books and a scientist at Brookhaven National Laboratory, where he conducts brainstorming sessions on the next seventy years in space. He has a cat named Phobos.

Oberg

(continued from page 53)

Oberg: They've spoken broadly and generally of that, but I think it's just talk. One has to say, though, that to judge intentions you have to look at preparatory steps. And assuming certain intentions, you then say, "Well, to make these intentions come true, the person would have to do A, B, C and D." Then, when you see the person actually *doing* A, B, C and D, you can say it's consistent at least with intention.

That's all we can say — that they're doing the right things now. If we had a program to send people to Mars at the turn of the century, we would be doing everything the Soviets are now doing. We would want a large booster program, and they're flight testing that now. You'd want long-duration hardware and long-duration human exposure to space conditions. You'd want unmanned scouting probes to Mars, including Phobos.

At some point, I would like to suggest they might be interested in a manned interplanetary sortie. That would involve a spacecraft on a months-long [journey], out perhaps several million miles from Earth and back. A single Energia [the new Soviet heavy-lift rocket] launch could carry that. It would carry a Salyut-type module with a Soyuz reentry vehicle, a two-man crew, out several million miles from Earth, just to get out into interplanetary space and back.

Now there's more than a stunt involved here, although it would look like it, because you're not going to any planet. There are actually a whole lot of things you could test in terms of communications and navigation, environmental exposure and reentry at speeds way in excess of escape velocity. So that kind of a test flight could be, I think, important.

Final Frontier: Have the Soviets talked about how they would do a Mars mission?

Oberg: They haven't talked specifically about how they would do it. They have no real strategy. There was a paper presented recently at a conference in Los Angeles where they talked about using ten Energias to land two Mars excursion modules on the surface of Mars, and 20 or so cosmonauts. But those kinds of things they redo from [Wernher] von Braun studies of 30 years ago. There's not a whole lot original.

Final Frontier: If you were comparing how far along Soviet manned Mars planning is, as compared to the U.S., who would you say is farther along in putting the pieces into place?

Oberg: In the space age you learn not to measure distance in miles. The same when you're measuring position relative to a finish line for a rabbit and a tortoise — you can't use a tape measure. You have to say, "Given the start-stop nature of American space funding, how soon, if there was national will behind it, could we do it?" And I think we could do it by the turn of the century or, say, within 8 to 10 years of a commitment. But the commitment itself is a bolt from the blue, or it comes from a foundation which people are trying to lay today.

The Soviets, on the other hand, have a very linear approach toward space, and they just keep plodding forward. They don't make startling progress in any one flight, but they do accumulate experience and enhance capabilities. So for a Soviet Mars strategy, I have to think of a number of intermediary steps that they would do first, including an unmanned interplanetary sortie.

Final Frontier: Could they do that in the very near future?

Oberg: I wouldn't say in the very near future. I'm saying in a number of small steps. But they take a long time to make the small steps. For them to plod toward this kind of goal, taking these intermediate steps as they go — which has been their habit — will take a long time. To have them *suddenly* do a manned Mars landing within the next 20 years is inconceivable. Give them credit for what they do right, but don't make them change their spots.

There are people in this country who want our rabbit to wear a shell and learn to creep. They want to develop a steady-state, long-term commitment toward space. Now, they can go ahead and tilt their lances at those windmills all they like, in my opinion. It's much more practical to say that we have to tailor our space program to the way America does space business, not the other way around.

The Soviet tortoise, though, cannot leap. There are projects they tried to do in the past that required great steps — their man to the Moon program, their Mars landing program — both of which failed very badly.

Final Frontier: Are you a skeptic when it comes to U.S.-Soviet cooperation in space?

Oberg: I think U.S.-Soviet cooperation is an excellent strategy, and I've been a long-term proponent of near-Earth, Shuttle/Salyut kinds of joint activities, even six to eight years ago, when it was deemed politically impractical. But I'm an opponent of trying to wish our way naively toward some kind of end goal. I'm also an opponent of rewriting history to say that [the] Apollo-Soyuz [joint mission in 1975], for example, aided international understanding. Apollo-Soyuz was a *result* of detente. It had no impact on diplomacy. In fact, it came at the end of the detente period. And that kind of very public space comradeship came at the same time that the Soviets were completing their greatest territorial expansion of client states in Southeast Asia and Africa and around the world.

Final Frontier: If we're both headed toward Mars, do you think it would be a mistake at this point to hitch our wagons together?

Oberg: People didn't hitch their Conestoga wagons together, but they did go in convoy. And going in convoy, operating parallel facilities, is not wasteful at all, because you tend to enhance the safety of each other's activities. If the Soviets were ever in trouble they could ask us for help, and vice-versa. The Soviet practice in the past has not been to ask for help. Their policy in the past has been to have their people die — literally — rather than admit problems. But there are some indications that this is changing and moving in a healthy direction.

Final Frontier: Then you see our Mars

efforts as two separate programs?

Oberg: I see it as two separate programs, yes, but still an entirely integrated joint project. You've got to realize that major levels of funding for space exploration will not come from any great desire to cooperate, especially over a 10- or 15-year period. I can't imagine any country, particularly the U.S., having the political perseverance to do that. Major funding has come from the desire to compete, to show that United States technology is world-class, or better — *off-world*-class — and to show that we are a great power.

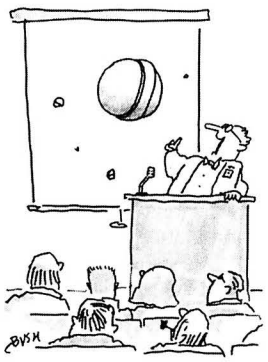
The Soviets know that. Their space program and their military program and their Olympic teams are the only things that really make them a great power. They have no other characteristics of anything but a second-rate, undeveloped country. And they know that their space program is the dues they pay for big league status.

Final Frontier: Doesn't that say they would dearly love to win one of these finish line-type races? They were clearly racing America to the Moon in the 1960s.

Oberg: They were clearly racing to the Moon, and they blew it. In terms of what they would get out of cooperating with the United States on a Mars program, it would no longer enhance their status to take the U.S. on as partners, with the status they've achieved right now.

Final Frontier: So they might not want to cooperate on a single, joint Mars mission?

Oberg: Well, they would like to cooperate in terms of holding it out as the carrot to cancel Star Wars. There are a lot of people calling for that, and I think it's a nit-wit notion, totally unworkable. We have a hard enough time cooperating with people we like, like the Europeans, who have a common background with us. □



Originally we thought it was made up of gasses, but on closer examination we realized it had a hard candy outside and a soft chocolate center.

Five Rocket Garage

(continued from page 31)

fied for the test vehicles. "Rather than starting from scratch," Truax explained, "we take an item that's pretty close to what we want and modify it to make it work."

Not all components could be found on the high tech auction block; the fuel tanks, for instance, were built from scratch. Most rocket fuel tanks are made from thin-skinned aluminum to conserve weight. Truax's tanks are built with high strength steel, which provides two important benefits. Because they are strong they can withstand the impact of an ocean landing without damage, which is necessary if the booster is to be reusable. Also, they allow Truax to use a pressurized fuel feed system, eliminating the need for expensive fuel pumps and turbines.

If the sub-orbital flights are successful, Truax hopes to continue onto phase two, the construction of an orbital booster with the payload capacity of the space shuttle. Called Excalibur, this new booster will be able to deliver payloads into low-Earth orbit for about $100 per pound, according to Truax's admittedly optimistic prognostications.

As currently envisioned, Excalibur will stand about 250 feet tall, weigh in at about 3.5 million pounds, and have a payload capacity of 100,000 pounds. The booster will have two stages, each with a single rocket engine. Liquid oxygen will be used on the first stage while liquid oxygen and hydrogen will power the second stage.

Excalibur will be launched from the land and retrieved from the ocean, just like the Enterprise test vehicles. Eventually, it will be launched from the ocean. It's just large enough to make a water launch slightly more economical than a land-based launch, says Truax.

As ever, money will be the stumbling block with Excalibur. Truax hopes that tests with the Enterprise vehicles will show potential investors the soundness of his designs. It will eventually cost $500 million to build and launch the first Excalibur. Compared to what it cost to build the first space shuttle, this is a "bargain basement price," Truax pointed out.

Once Excalibur proves itself, Truax will be ready for phase three, the Sea Dragon. Based upon the vehicle Truax worked on while at Aerojet in 1963, Sea Dragon will stand over 500 feet high, weigh some 40 million pounds at lift-off and have a 1,000 ton payload capacity. In comparison, NASA's Saturn 5 booster stood 360 feet high, weighed 6.4 million pounds, and delivered some 100 tons to low-Earth orbit.

Sea Dragon will be processed in a dry dock facility between missions. Before each launch, the vehicle, with its payload in place, will be towed out to sea where it will be fueled by tankers and erected to a vertical launch position by flooding ballast tanks attached to its bottom.

There are very reasonable doubts as to whether Bob Truax will ever see his dream come to fruition. A smart bookie would give the California rocket entrepreneur pretty long odds, especially when you consider the problems that are facing large, well-funded aerospace firms trying to build their own launchers.

Then there's the matter of age: "I'm pushing 70 with a pretty short stick," the rocket designer admits. While most men his age have retired, Truax has begun a project that could easily span the lifetime of a much younger person.

But despite the odds against him, Truax has every intention of seeing his latest project fly. After all, he's been at this game for almost 50 years. □

Robert Nichols is a freelance writer living in Brockton, MA.

R.S.V.P.

(continued from page 50)

felt about themselves. Yet why should someone else's later acts so alter one's feelings about one's own?) But the universe, it would appear, is not a poem. No messages to them were detected. Light from the outbursting of their star reached Earth as their broadcasts (should they have terminated them a year and a quarter before the end?) and their plays and their science and their philosophy, their hopes and their fears and their courage and their living glow ended.

Some people used to think it would be terrible to discover that human beings were the only intelligent beings in the universe, because this would lead to feelings of loneliness on a cosmic scale. Others used to think that discovering intelligent beings elsewhere would remove their own last trace of uniqueness and make them feel insignificant. No one, it seems, had ever speculated on how it would feel to allow another civilization to vanish feeling lonely, insignificant, abandoned. No one had described the horrendousness of realizing that the surrounding civilizations are like one's own: of realizing that each neighbor remaining in the universe, each of the only other ones there are, is a mute cold wall. Limitless emitlessness. Lacking even the comfort of deserving better, facing an inhabited void.

Robert Nozick is the Arthur Kingsley Porter Professor of Philosophy at Harvard University, and the author of Anarchy, State and Utopia *and* Philosophical Explanations. *A longer version of this story appeared originally in* Commentary *magazine.*

Is Anybody Listening

(continued from page 47)

a princess in the fictional land of Oz) at the National Radio Astronomy Observatory in Green Bank, West Virginia—150 hours of observations of two nearby stars, Tau Ceti and Epsilon Eridani, using a one-channel receiver hooked up to an 85-foot-diameter telescope. Oliver was so taken with the story that the next time he visited Washington on business he made a side trip to Green Bank to visit Drake, who invited him to an upcoming SETI conference. Although Oliver spent 30 years at Hewlett Packard as vice president for research and development before coming to NASA, he's been deeply involved in the SETI community ever since that first meeting with Drake. In that time, there have been 40 or so small-scale searches for extraterrestrial intelligent signals conducted around the world, in the Soviet Union, France, West Germany, Australia, and elsewhere.

But for reasons no one seems to fully understand, NASA's low budget, publicly popular, technically advanced SETI program has led a star-crossed life since it was born.

In February 1978, big trouble dropped in the space agency's lap. Senator William Proxmire, penny-pinching Democrat of Wisconsin, gave the agency one of his famous and embarrassing Golden Fleece awards for allegedly wasting money on such a useless enterprise as listening for messages from extraterrestrials. Proxmire sat on the Appropriations Committee, so he had clout. He fought against SETI and succeeded in barring NASA from spending any money on it. That brought in Carl Sagan to meet with Proxmire, and Barney Oliver to talk with the Senator's aide. At last they dispelled Proxmire's concerns, although he relented only when convinced that SETI technology might be used for other earthly gains. But the Senator did not—and still does not, according to his aide — believe that intelligent life exists in places other than Earth. And some SETI people are still jittery about possible new attacks from the soon-to-retire Proxmire.

"We're going to verify, verify, and verify before we're going to release any kind of announcement. . . . No one, no one, wants to cry wolf."

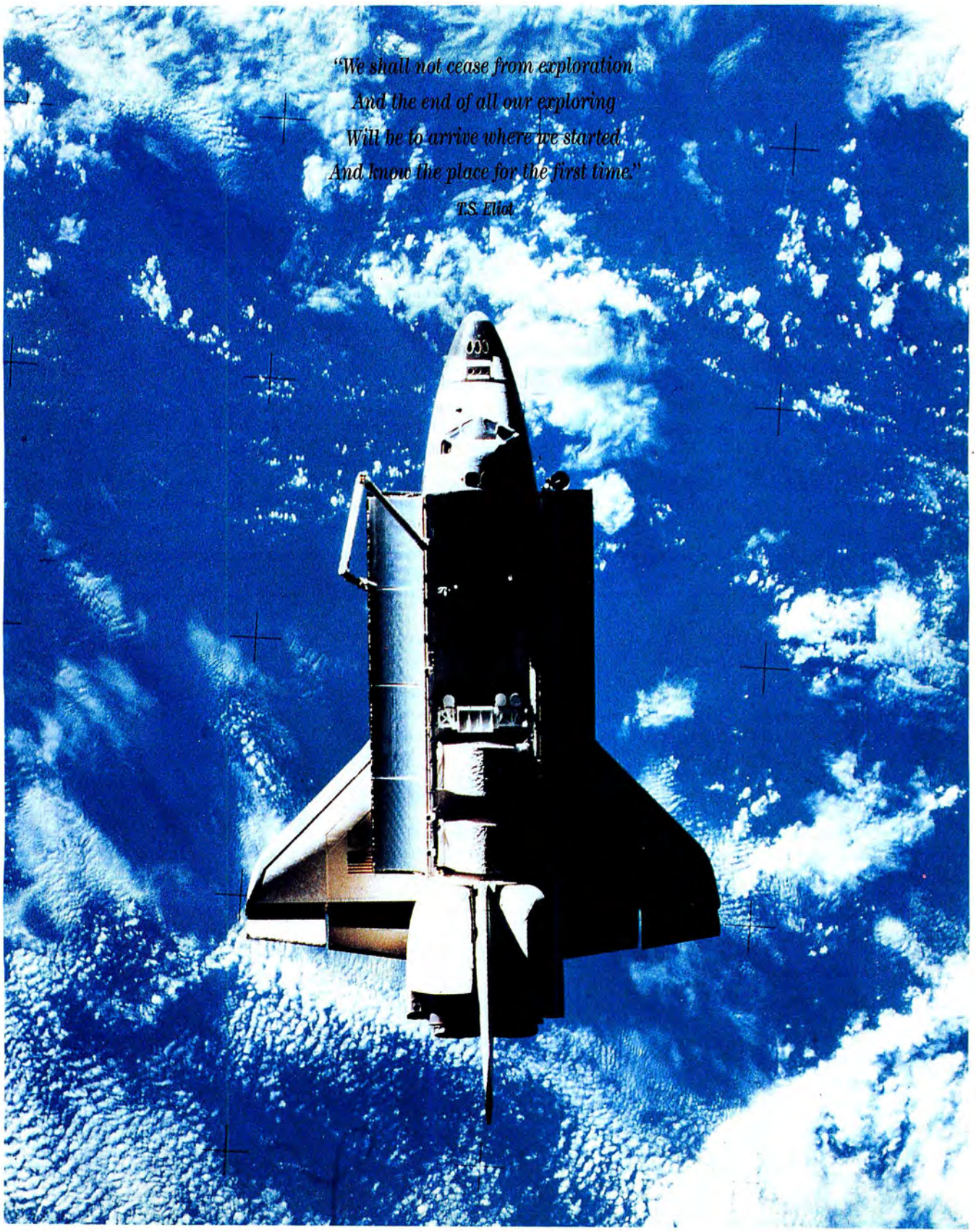
▼ ▼ ▼

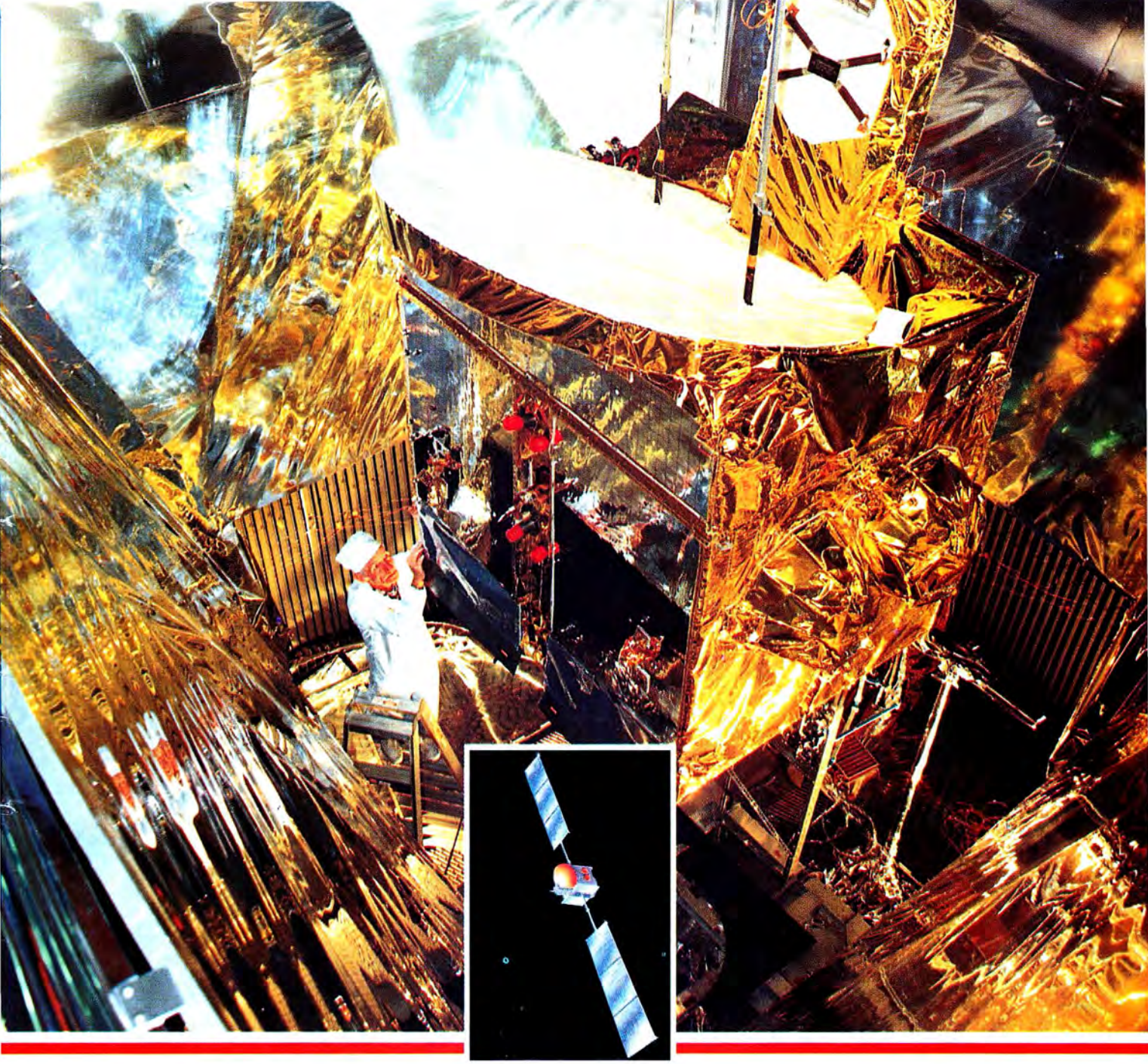
Since 1983, SETI's stock has gone up in Washington. White House Science Advisor William Graham last year set up a meeting between Oliver and Chief of Staff Howard Baker. Oliver said the two talked for half an hour and Baker, an astronomy buff, seemed very interested. In August 1987, White House Office of Management and Budget Director James Miller asked for a briefing on SETI and UFOs, out of personal curiosity. NASA sent over the experts fast.

The SETI people will probably never find out whether these meetings had anything to do with their budget success this year. But if Congress doesn't muck things up, the program will be off to a good start this fall. Lynn Griffiths has a lot of confidence in her SETI people. She tells a story about a team that stayed up all night on a weekend working on a last-minute refinement to a piece of SETI prototype hardware scheduled to be fabricated the following week: "They went through this heroic effort, and they got it done. They were all excited. It was great work, which is typical of SETI. SETI people will do anything to make their deadlines. They're one of the world's magic teams." □

Linda Billings is a Washington, D.C. writer who specializes in space topics.

DESTINATIONS





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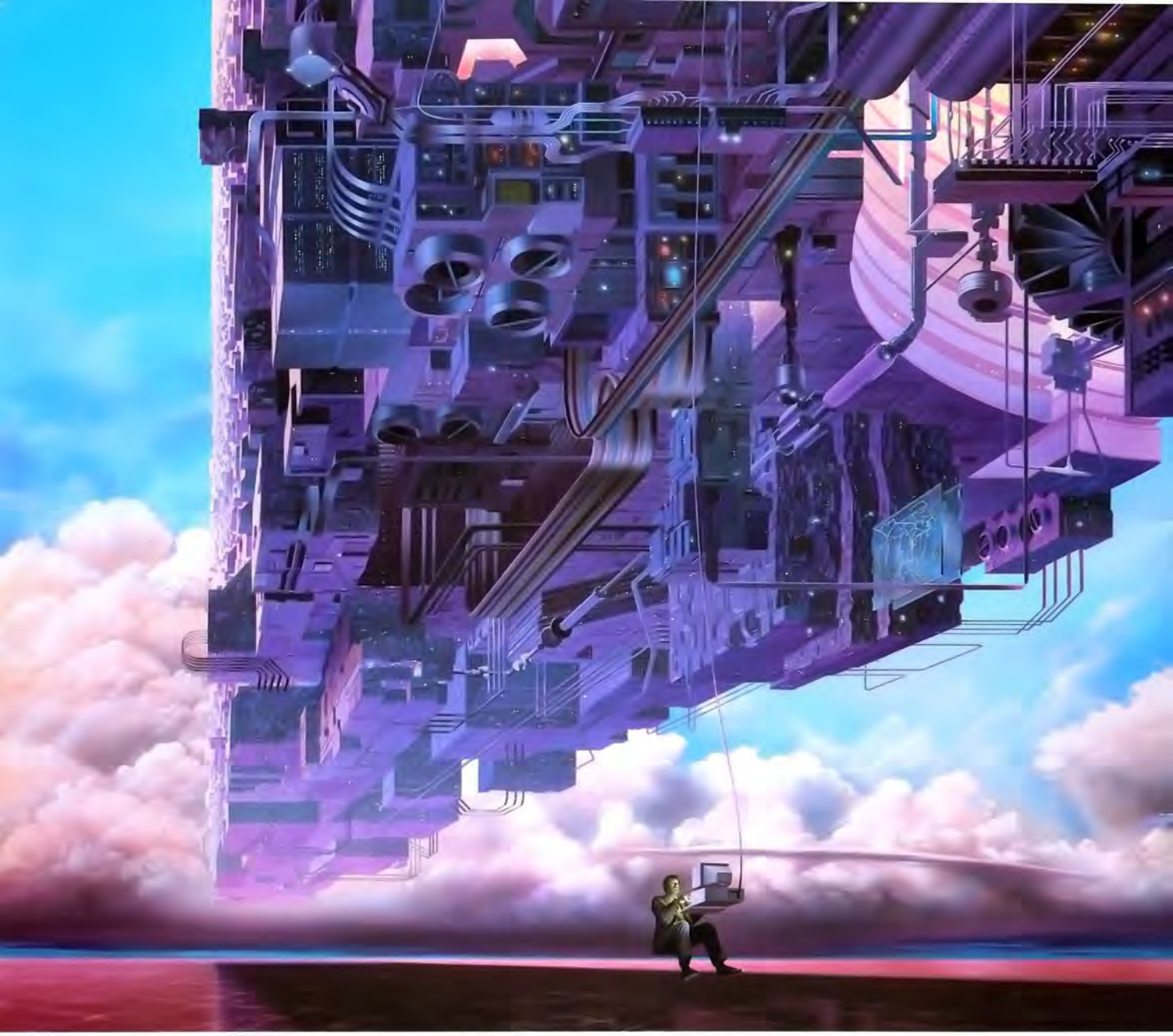

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